TEXTILE RESEARCH JOURNAL

VOLUME XXV May, 1955 NUMBER 5

National Cotton Council of America Sixth Cotton Research Clinic

PUBLICATION OF

TEXTILE RESEARCH INSTITUTE

Editorial Office: 10 East 40th Street, New York 16, N. Y.

TEXTILE RESEARCH JOURNAL

VOL. XXV, NO. 5 MAY 1955

The Sixth Cotton Research Clinic

of the

National Cotton Council of America

Pinehurst, North Carolina

February 16, 17, 18, 1955

General Chairman

M. EARL HEARD
Vice-President in Charge of Research
West Point Manufacturing Company

Session Chairmen

EMMETT W. BRINGLE
Technical Department
National Cotton Council of America

W. GORDON MCCABE, JR.
Vice-President
J. P. Stevens & Co.

HERMAN A. DICKERT
Dean, School of Textiles
Georgia Institute of Technology

THOMAS G. HAWLEY
Director of Research
United Merchants' Laboratories

Editor: **Julian S. Jacobs** ***Production Editor:*** **Elizabeth Jane Cassatt**

Associate Editors

H. J. Ball **W. J. Hamburger** **Harold P. Lundgren**
Earl E. Berkley **Milton Harris** **H. Mark**
Henry Eyring **K. L. Hertel** **E. R. Schwarz**

TEXTILE RESEARCH JOURNAL, published monthly at Prince and Lemon Streets, Lancaster, Pa., is devoted to the interest of research in textile and allied industries. It is published by Textile Research Institute.

Entered as second-class matter, April 27, 1945, at the post office at Lancaster, Pa., under the Act of August 24, 1912. Accepted for mailing at special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948, authorized May 9, 1950.

Manuscripts and communications should be sent to the editorial office, 10 East 40th Street, New York 16, N. Y.

Subscription rates: $15.00 per year; additional for postage, 50 cents to Canada, $1.00 to all other countries. Single copies, $1.50 each.

Contents copyrighted 1955 by Textile Research Institute. Advertising rates supplied on request.

Foreword

In the six years since the first Cotton Research Clinic was held, attendance at this meeting has more than quadrupled. The 1955 Clinic at Pinehurst, North Carolina, drew conferees from textile manufacturers, machinery builders, educational institutions, government and private laboratories, cotton merchants, and other major segments of the industry. Manufacturing executives representing more than one-half of the cotton spindles in the United States composed the largest segment of the 250 registrants at the Clinic. From outside this country, interested manufacturers attended the Clinic from England, Germany, Holland, Sweden, Canada, Peru, and Israel. The program again included a speaker from Europe.

The continued growth and success of the Cotton Research Clinic indicates several things. First, the Clinic has become the cotton industry's most important technical conference because of its sound programs and careful planning. Secondly, interest in cotton-processing developments and recognition of the potentialities of cotton are increasing, year by year. Finally, increased attendance at the Clinic and, especially, foreign participation demonstrate the leadership of this country in cotton textile manufacturing methods.

Growth in size itself presents a problem, but losses in personal exchange occasioned by a large meeting must be balanced against the benefits of a wider dissemination of research findings and a wider interest in cotton problems.

This publication of papers presented at the Clinic, carried in full by the Textile Research Journal *for the second time, should importantly extend the benefits of the Clinic by bringing its findings to a still wider audience. Through this medium it is hoped that greater interest may be stimulated in the opportunities cotton holds for the entire textile industry.*

M. Earl Heard
Vice-President in Charge of Research
West Point Manufacturing Company
Shawnut, Alabama

In This Issue

THE CONTROL OF CARDING WASTES. J. F. Bogdan 377

REDUCING WASTE AT THE CARD. E. Allen Bentley 385

A METHOD OF REDUCING CARD WASTE. Hugh M. Brown, J. L. Thompson, and J. S. Graham 388

HIGH-PRODUCTION CARDING. S. H. Sherman 393

COMMERCIAL SPINNING TESTS ON PIMA S-1. Burt Johnson . . 396

EVALUATION OF YARN PROPERTIES AND PROCESSING PERFORMANCE OF PIMA S-1 COTTON. John J. Brown, Nathaniel A. Howell, Louis A. Fiori, and Jack E. Sands 404

THE EFFECT OF AN EXCESSIVE GIN-DRYING TEMPERATURE OF COTTON ON YARN QUALITY AND MILL PROCESSING. W. J. Hart, T. L. W. Bailey, Jr., William R. Keyser, Jr., and Jack Compton 415

COTTON FIBER LENGTH DISTRIBUTION—AN IMPORTANT QUALITY FACTOR. Helmut Wakeham 422

SPEEDAR MEASUREMENT OF FIBER FINENESS AND COMPRESSIBILITY. K. L. Hertel and C. J. Craven 429

MANAGEMENT OF QUALITY CONTROL IN COTTON MANUFACTURING. Oliver P. Beckwith 433

JOANNA MILLS QUALITY TESTS AND VARIATION CONTROL METHODS. Joseph L. Delany 440

MANAGEMENT OF QUALITY—STUDIES ON COTTON YARN IMPERFECTIONS. Charles C. Wilson 446

MANAGEMENT OF QUALITY. William J. Blydenstein 452

EFFECT OF COLLOIDAL SILICA TREATMENTS ON COTTON PROCESSING CHARACTERISTICS AND YARN QUALITY. Hugh M. Brown, J. H. Langston, and W. T. Rainey, Jr. 462

THE EFFECT OF FABRIC STRUCTURE ON FABRIC PROPERTIES. John J. Brown and Ralph A. Rusca 472

THE SRRL CARDING CLEANER. George J. Kyame and Mayer Mayer, Jr. 476

TEK-JA: A NEW APPROACH TO TWISTLESS YARNS. Richard D. Wells 481

PROCESSING EQUIPMENT FOR TEK-JA YARN. John W. Powischill . 486

BOOK REVIEWS 490

TEXTILE RESEARCH JOURNAL

VOL. XXV, NO. 5 MAY 1955

The Control of Carding Wastes[1]

J. F. Bogdan

Director of Processing Research, North Carolina State College, School of Textiles

Abstract

Carding wastes can be reduced on the average by about one-half (2¾% of lap weight) without lowering yarn appearance or yarn strength. Flat strips and motes and fly comprise about ¾ of the total carding wastes; it is in the control of these wastes that the greatest saving is realized.

How the Tests Were Made

The results presented in this report are based on work in which full-size production machines were used under conditions duplicating mill processing conditions as closely as possible. The cottons used were supplied by the supporting mills in picker-lap form to eliminate variables in opening procedures.

This work is an extension of the research on nep control which was conducted at North Carolina State College [1]. Speeds and settings recommended in that report, such as high licker-in speed, were used as the basis for experimentation. Speeds and settings were altered one at a time from subnormal to abnormal. After the effects of individual variables were determined, tests in which the variables were integrated were made.

In all cases yarns furnished by each mill and data on the manufacturing organizations for each mill were used as controls. Additional controls were provided by the manufacture of yarns at North Carolina State with the mill's manufacturing organization.

For each experiment fiber was carded for 2 hr and only the sliver from the last ½ hr of the run was processed into yarn. Test values of yarn strength, yarn number and appearance, wastes, etc., were recorded for each sample processed, and the data subjected to the usual yardsticks for variation and dependability.

The cottons used in the series of tests are shown in Table I.

The savings realized in experimental processing when using the recommended settings shown in Table II are listed in Table III with the count-strength products of the yarns produced. The wastes are plotted in Figure 1.

Mill Application of Recommendations

One of the participating mills (Mill *A*) applied the recommended card speeds and settings to half of their cards and submitted their biweekly mill-waste figures

TABLE I. Cottons with Which North Carolina State Worked

Mill	Territory	Staple Length (in.)	Grade
A	Carolinas	1	LM
B	—	15/16	LM
C	Miss. Delta	1 1/16	SM
D	Miss. Delta	1 1/16	SM
E	Eastern (50%)	1 1/32	SLM
	Arizona (50%)	1 1/16	
F	—	1	M

[1] The work described in this report is based on a research project sponsored at the School of Textiles, North Carolina State College, by six cotton spinning mills who retained the results exclusively for one year after the completion of the project and who now present these results to the industry. The sponsoring mills are: Avondale Mills; Burlington Mills Corporation; Randolph Mills, Inc.; J. P. Stevens and Company, Inc.; Swift Manufacturing Company; and Textiles, Inc.

TABLE II. Recommended Carding Speeds and Settings for Waste Reduction

Speeds	
Licker-in (rpm)	800
Cylinder (rpm)	165
Doffer (rpm)	Mill production
Flats (in./min)	0.40
Doffer comb (cpm)	Depends on production
Settings	
Feed plate to licker-in	12
Mote knives to licker-in	
Top	7
Bottom	7
Top mote knife to feed plate (in.)	1
Bottom mote knife to bars (in.)	7/8
Top edge of back plate to flats	10
Mote knife angle (degrees)	30
Licker-in screen to licker-in	
Back	10
Middle	10
Front	10
Licker-in to cylinder	7
Back knife plate to cylinder	
Top	22
Bottom	68
Flats to cylinder	
Back	7
Intermediate	7
Intermediate	9
Intermediate	10
Front	12
Flat stripping comb to flats	15
Front knife plate to flats	10
Front knife plate to cylinder	
Top	34
Bottom	34
Doffer to cylinder	5
Doffer comb to doffer	17
Cylinder screen to cylinder	
Back	29
Center	68
Front	187
Type of licker-in screen	Grid (7¼ in.)
Type of cylinder screen	Grid

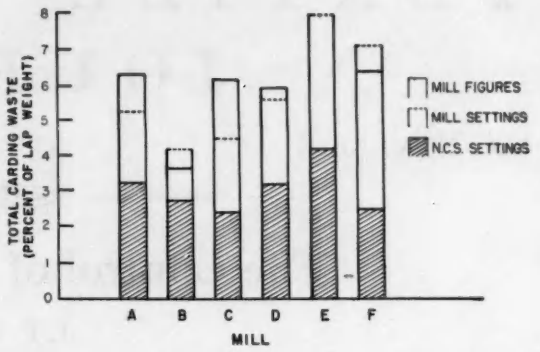


Fig. 1. Carding wastes obtained by mills using regular settings, by North Carolina State using mill settings, and by North Carolina State using North Carolina State settings.

for a period of 40 weeks before the change and 50 weeks after. This mill is operating currently with a card-waste reduction for the mill of 1¼% of lap weight, which means that those cards which have been changed to the North Carolina State recommendations are operating with a saving in carding waste of 2½% of lap weight.

The waste figures submitted by Mill *A* are shown in Table IV and are plotted in Figure 2.

Another mill has estimated that the waste reduction of 1½% of lap weight which they have realized will mean a yearly saving to the mill of $35,000 per 100 cards.

Types of Carding Wastes

Any program concerned with reducing waste must deal with the two main categories of waste: preventable and so-called nonpreventable.

TABLE III. Effect of Recommended Settings on Card Wastes and Yarn Strength

Per Cent of Lap Weight

	Total Carding Waste			Savings		Count Strength Product	
Mill	Mill Waste Figures	N.C.S. Carding Mill Settings	N.C.S. Final Settings	Over Mill Figures	Over N.C.S. Carding Mill Settings	N.C.S. Carding Mill Settings	N.C.S. Final Settings
A	6.30	5.24	3.20	3.10	2.04	1917	1968
B	3.60	4.16	2.72	0.88	1.44	1912	2012
C	6.14	4.48	2.31	3.83	2.17	1932	2071
D	5.91	5.57	3.15	2.76	2.42	2470	2438
E	—	7.96	4.16	—	3.80	2305	2329
F	6.36	7.06	2.49	3.87	4.57	2027	1999
Average Saving				2.89	2.74		

TABLE IV. Mill A: Carding Wastes by Biweekly Periods (Per Cent of Lap Weight)

Biweekly Period	Flat Strips	Motes and Fly
	1953	
	Before Change	
1	2.911	2.199
2	3.277	2.364
3	3.074	1.848
4	2.783	1.493
5	3.201	2.054
6	3.052	1.982
7	3.420	2.281
8	3.321	2.248
9	3.048	1.986
10	3.176	2.101
11	3.166	2.052
12	3.407	2.339
13	3.344	2.270
14	3.370	2.169
15	3.185	2.195
16	3.169	2.198
17	3.161	2.179
18	3.141	2.141
19	3.298	2.273
20	3.110	2.253
Mean	3.231	2.131
	Beginning of Change	
21	2.689	2.050
22	2.869	2.109
23	2.618	1.933
24	2.706	2.081
25	2.657	2.105
26	2.532	2.056
	1954	
	After Change	
1	2.459	1.878
2	2.544	2.004
3	2.506	1.736
4	2.563	1.733
5	2.749	1.799
6	2.756	1.816
7	2.554	1.653
8	3.072	1.909
9	2.731	1.722
10	2.486	1.809
Mean	2.642	
	Change Completed on One Half of the Cards	
11	2.116	1.655
12	2.215	1.690
13	2.229	1.701
14	2.193	1.686
15	2.413	1.981
16	2.277	1.812
17	2.300	1.842
18	2.165	1.847
19	2.473	2.083
Mean	2.264	1.808

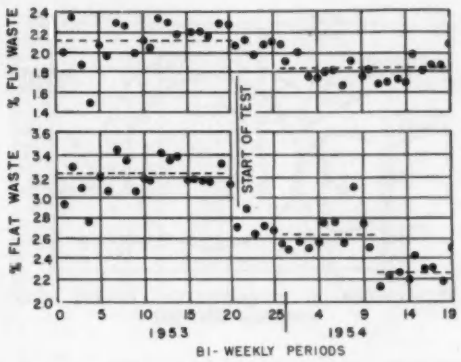


Fig. 2. Results obtained by mill *A* in applying recommendations for waste reduction.

Preventable waste has been described as waste arising from end breaks, careless operators, etc. Commonly called "reworkable" waste and often "white" waste, it is not purposely removed and is composed of perfectly good material. Most waste-reduction programs deal with this category of waste.

Nonpreventable waste has been defined as waste removed in the process of cleaning the fiber or during other manufacturing functions. Commonly called nonreworkable waste, it is purposely removed. Since it cannot be returned to the normal manufacturing process, it is true waste, although most of it has some sales value as waste.

The research on which this report is based was aimed at preventing, or at least substantially reducing, this so-called nonpreventable waste.

Cotton-card waste is divided into the following eight categories: (1) Motes; (2) Fly; (3) Cylinder strips; (4) Doffer strips; (5) Flat strips; (6) Clearer waste; (7) Sweeps; and (8) Reworkable waste.

Motes represent the heavier type of waste found beneath the licker-in. They are composed of seed, seed fragments, leaf, trash, and lint removed by the opening and cleaning action of the licker-in and mote knives.

Fly is the lighter and cleaner waste composed of relatively short fibers that are thrown out between the openings of the mote knives and licker-in and cylinder screens. In practice, motes and fly are usually combined as one type of waste to facilitate cleaning beneath the card without attempting to separate these wastes.

Cylinder strips are the waste removed from the cylinder by vacuum or roll stripping at the end of

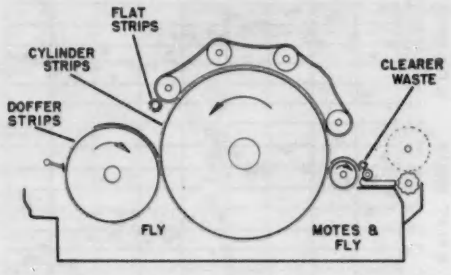


Fig. 3. Location of "nonpreventable" carding wastes on revolving flat card.

the stripping cycle. Cylinder strips are composed of essentially normal-length fibers that become embedded in the clean clothing when the card is started after stripping; however they also contain shorter fibers and trash that accumulate during the processing period.

Doffer strips are the waste removed from the doffer at the end of the stripping cycle. The composition of this waste is similar to that of the cylinder strips. Cylinder strips and doffer strips are combined and are sold as vacuum strips.

Flat strips are the fibers and trash that result from the carding action between the cylinder and the flats. These strips contain a large amount of usable fiber and are the most valuable of card wastes.

Scavenger or clearer waste is the waste collected by the revolving flannel-covered clearer roll at the small opening between the licker-in cover and the feed roll. This waste is composed of relatively short fibers that are carried around by the air set in motion by the licker-in.

Sweeps are the waste swept from the floor around the card. Sweeps are composed mainly of lint but may contain a considerable amount of foreign matter.

Reworkable carding waste is composed of pieces of picker lap removed in starting a new lap and running out an old lap, short lengths of sliver, and the soft roll of fibers formed by the doffer comb when the card is started.

The control of the last two wastes, sweeps and reworkable, is a management problem, the solution of which depends on the proper instruction of picker tenders and card tenders.

The first six types of waste can be controlled to a large extent by mechanical changes in speeds, settings, and modifications of the card. It is with these wastes and the changes that affect them that we are concerned in this report.

The location of these so-called "non-preventable" wastes is shown in Figure 3.

Distribution of Carding Wastes

The average total carding waste reported by 20 cotton mills is about 6% of lap weight. The average carding waste reported by the sponsoring six mills at the beginning of this project was 5¾%.

The distribution of the five major categories as percentages of these total carding wastes is about as follows:

Flat strips	45%
Motes and fly	33%
Cylinder strips	16%
Clearer waste	3.5%
Doffer strips	2.5%
Total	100%

Figure 4 shows the comparison of these relative amounts of carding wastes.

Figure 5 shows the average saving of each of these types realized when using the recommended speeds and settings.

Since flat strips and motes and fly comprise ¾ of the carding waste, it is apparent that the greatest saving can be realized by attention to the control of these wastes.

Control of Motes and Fly

The amount of motes and fly removed by the action of the licker-in, mote knives, and licker-in screen can be reduced to zero by using a solid licker-in screen that extends from the feed plate to the cylinder. This type of screen is used for carding many synthetic fibers, where cleaning is not one of the necessary functions of the card. This arrangement would not be satisfactory for processing cotton, however, since the trash found in the normal motes and fly waste would be carried to the cylinder, disintegrated between cylinder and flats, and carried forward into the sliver.

At the other extreme, it is possible to process cotton experimentally without using mote knives or licker-in screen, but under these conditions the amount of waste found beneath the licker-in is prohibitively high in good lint content.

Somewhere between these extremes lies the optimum condition for each variety of cotton.

The amount of motes and fly removed at the licker-in depends on the extent of the openings

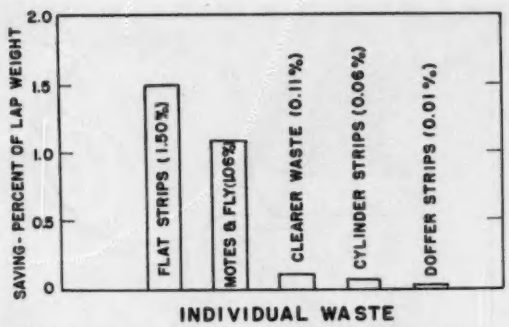


Fig. 4. Relative amounts of carding wastes by type found in industry.

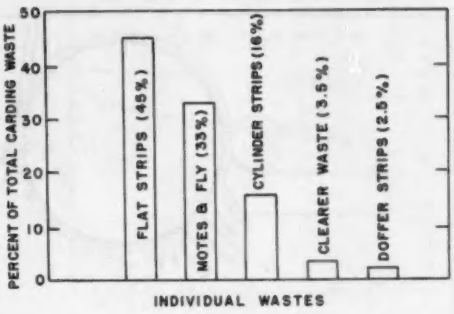


Fig. 5. Waste savings by type when using recommended speeds and settings.

between the feed roll, mote knives, and licker-in screen and the distribution of these openings.

One of the simpler ways to reduce the amount of motes and fly is to relocate the position of the mote knives. The normal schedule of card settings specifies the distance between the mote knives and the licker-in and the angle of the top mote knife to the vertical. The distance between the top mote knife and the edge of the feed plate affects waste removal at these points, but this distance is not usually controlled.

Moving the mote knives to a setting between the top mote knife and the feed plate of $1\frac{1}{4}$ in. instead of $1\frac{7}{8}$ in. reduces fly waste about 0.8% of lap weight. The final setting places the mote knives about midway in the opening between feed plate and licker-in screen.

Figure 6 shows the incorrect location of mote knives with reference to the feed plate and licker-in screen. The mote knives are located properly in Figure 7.

Increasing the licker-in screen length by $\frac{5}{8}$ in. along the curved dimension reduces fly waste about 0.6% of lap weight because of the decrease in the opening through which lint can be thrown out by the licker-in. Figure 8 illustrates how excessive lint loss occurs with a short screen.

Any means of reducing the openings through which lint can be thrown out reduces the amount of motes and fly removed. Figure 9 illustrates how the addition of a horizontal mote knife reduces this type of waste.

Control of Flat Strips

It is in the control of flat strips that the greatest saving can be made. There is no reason to assume that the normal flat speed of 3 to $3\frac{1}{2}$ in. per min is the best speed for all grades of cotton and all production rates. This speed will be found in mills carding long-staple Egyptian cotton at 5 lb per hr and in others carding $\frac{15}{16}$ in. Good Ordinary at 20 lb per hr.

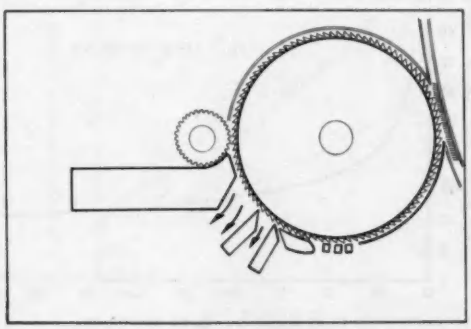


Fig. 6. Incorrect location of mote knives with reference to feed plate and licker-in screen.

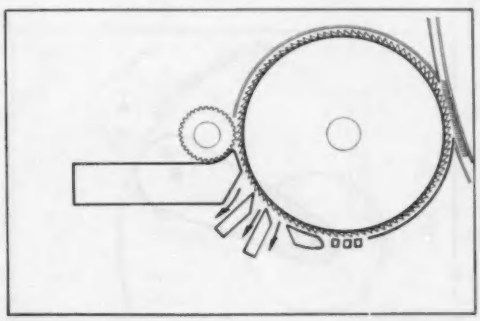


Fig. 7. Correct location of mote knives with reference to feed plate and licker-in screen.

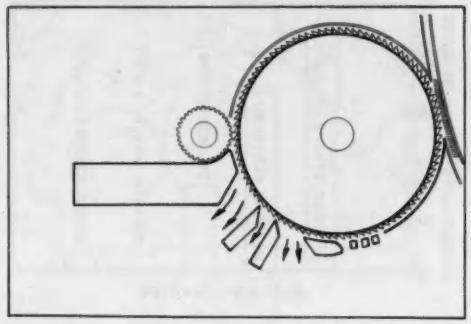


Fig. 8. Excessive fly waste produced with short licker-in screen.

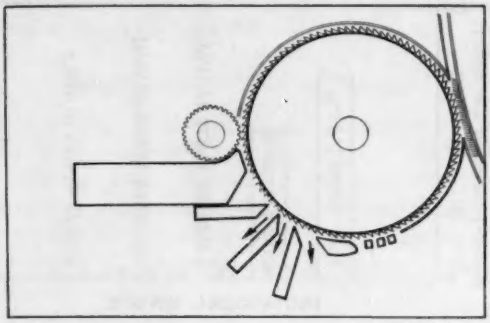


Fig. 9. Addition of third mote knife fastened to feed plate reduces openings in licker-in assembly and saves motes and fly waste.

The rate of increase of flat strips with flat speed is essentially constant. This means that the amount of flat strips is almost directly proportional to flat speed, so that a reduction in this waste can be accomplished by slowing the speed of the flats. Mills can cut the amount of flat strips in half by removing the cylinder pulley which drives the flat pulley and running the belt on the hub (Figure 10).

To achieve lower flat speeds will require a change in the flat pulley diameter or in the number of teeth in the worm wheel.

The amount of stock retained by each flat is not proportional to speed. Flats tend to load quickly at the beginning of their cycle of contact with the cylinder (Figure 11). After the flats have become partially loaded they tend to resist the tendency of fibers to enter this space, but they do not appear to prohibit the entrance of leaf and trash. The fibers which are held by the flats tend to cling to many of the leaf and trash particles and prevent their being carried forward into the sliver.

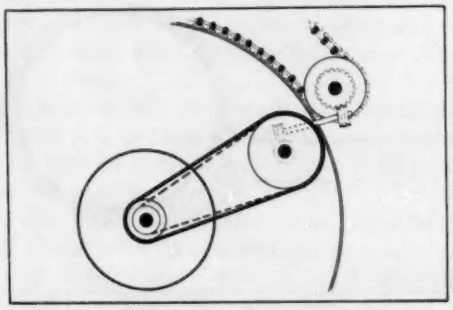


Fig. 10. Flat speed reduced by removing cylinder pulley and driving from hub.

An inspection of the inner and outer surfaces of the flat strips shows a difference in cleanliness, which supports the contention that the flats are partially loaded at the beginning of the cycle with normal material and then choose trash particles in preference to lint (Figure 12).

Carding waste and yarn results obtained with a wide range of flat speeds in the regular and in the reverse direction indicate that slowing the flat speed will neither materially decrease yarn strength nor affect yarn appearance. Flats running in the reverse direction (opposite to rotation of cylinder) remove more flats strips at a given speed than flats which run in the normal direction (Figure 13). The increase in flat strips with flat speed causes a consequent decrease in sliver delivery (Figure 14).

The weight of the average flat strip per flat decreases with flat speed, but the rate of decrease is low (Figure 15).

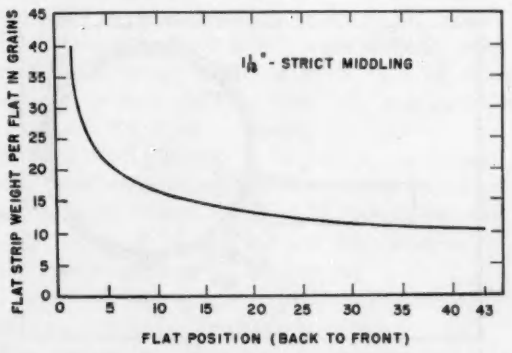


Fig. 11. Flats tend to load quickly at the beginning of their cycle of contact with the cylinder.

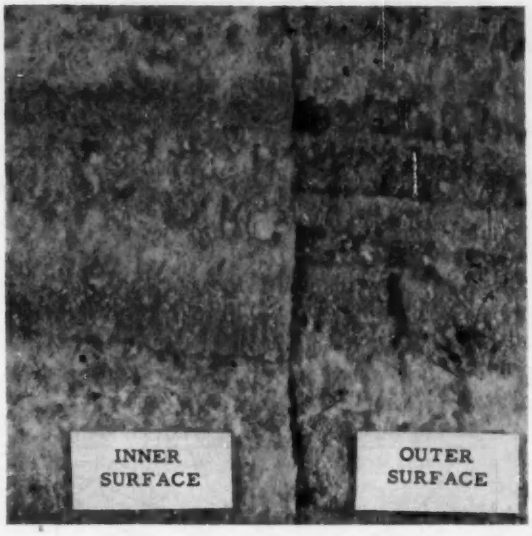


Fig. 12. Relative trash content of inner and outer surfaces of flat strips.

Table V shows that the flat strips removed with the lower flat speed recommended have a higher trash content than when processing at normal conditions (Figure 16). The motes and fly wastes removed with the recommended settings also show a higher trash content (Figure 17).

Control of Cylinder and Doffer Strips

The amount of cylinder strips depends on the manner in which fibers are presented to the cylinder by the licker-in. This in turn depends upon licker-in

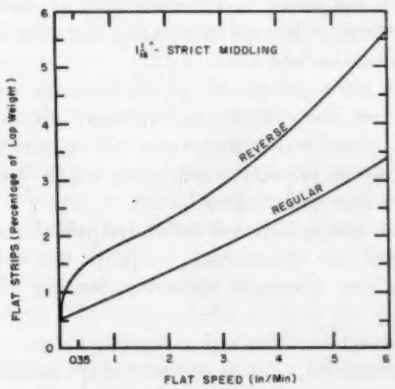


Fig. 13. Effect of flat speed and direction on removal of flat strips.

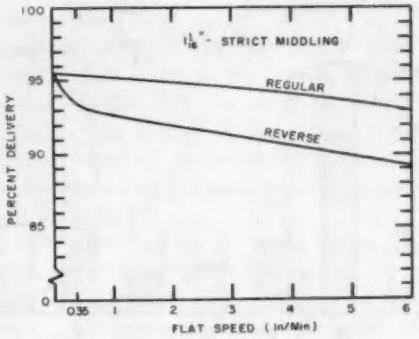


Fig. 14. Effect of flat speed on sliver delivery.

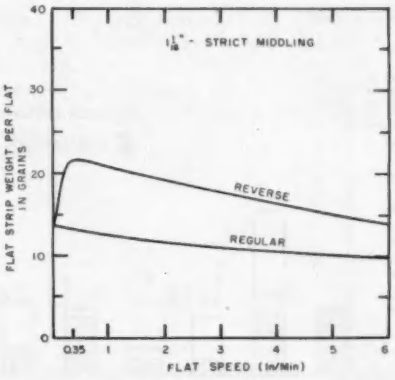


Fig. 15. Effect of flat speed on flat strip weight per flat.

TABLE V. Shirley Analyzer Tests on Flat Strips and Motes and Fly (Mill Organization vs. North Carolina State Recommended Settings)

Mill	Card Settings	Ratio: Trash/Lint Motes and Fly	Flat Strips
A	Mill	2.0	0.29
	N.C.S.	8.4	0.41
B	Mill	2.4	0.11
	N.C.S.	4.9	0.28
C	Mill	0.4	0.08
	N.C.S.	1.8	0.13
D	Mill	0.5	0.07
	N.C.S.	0.8	0.13
E	Mill	1.7	0.20
	N.C.S.	2.0	0.34
F	Mill	0.6	0.08
	N.C.S.	2.2	0.14

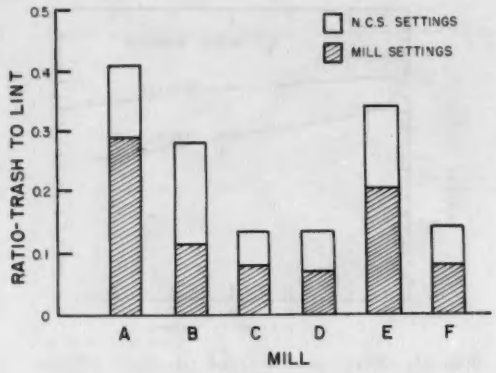


Fig. 16. Shirley Analyzer tests of flat strip waste.

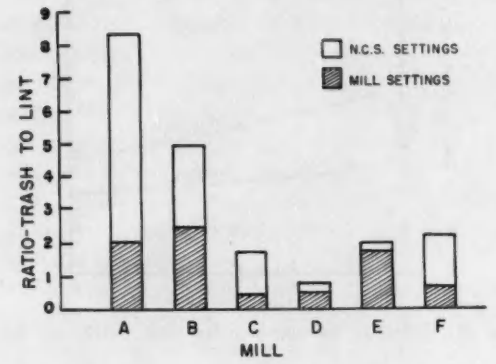


Fig. 17. Shirley analyzer tests of motes and fly waste.

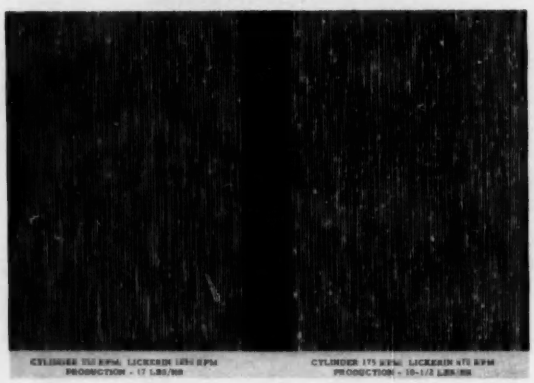


Fig. 18. High cylinder and licker-in speeds remove trash more effectively, producing a yarn of better appearance and 9% better strength.

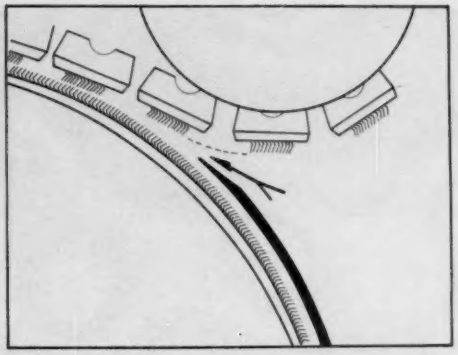


Fig. 19. Setting between top edge of front knife plate and flats.

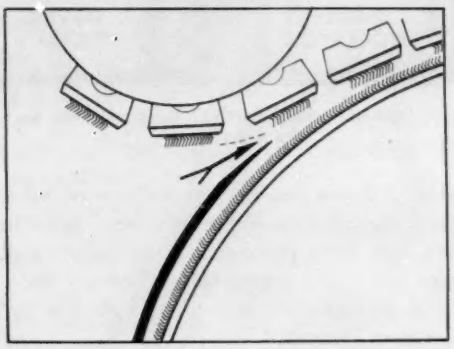


Fig. 20. Setting between top edge of back knife plate and flats.

speeds and the degree of openness of the picker lap. High licker-in speeds tend to open up fiber bundles and distribute fibers more equally on the cylinder. A picker lap which is relatively free of unopened tufts will make the task of opening and distributing fibers an easier one.

Large tufts presented by the licker-in will be pressed into the cylinder by the flats. Small tufts will be opened more easily and will remain at the surface of the cylinder wires, from which they can flow onto the doffer sliver.

A close setting between doffer and cylinder allows the doffer an opportunity to keep the cylinder stripped and prevents excessive loading of the cylinder.

The extent of doffer strips depends on the control of cylinder strips. Where cylinder strips are reduced by better fiber control it will be found that doffer strips are reduced also.

A high licker-in speed with its additional centrifugal force removes more of the heavy particles in the lap. Figure 18 shows the comparison of conventional processing on a mix composed of flat strips and the effect of high cylinder and proportionally high licker-in speed. The improvement in yarn appearance with the high speeds is apparent.

Control of Clearer Waste

Clearer or scavenger roll waste can be reduced by moving the licker-in cover toward the feed roll to decrease the slotted opening between the licker-in cover and the feed roll through which the clearer waste is blown by the fanning action of the licker-in.

Opening the setting between the bottom edge of the back-knife plate and the cylinder allows more air to flow from the licker-in to the cylinder, decreasing the air pressure at the licker-in. This reduces clearer waste.

Control of Air Currents

The setting between the top of the front-knife plate and the flats is not varied usually (Figure 19). Cheng and Morton [2] discussed the influence of variations in this setting on flat strips. Our own experiments show an improvement in yarn appearance when this setting is closed from the usual setting of 0.068 in. to 0.010 in.

The setting between the top of the back-knife plate setting and the flats (Figure 20) is also not usually changed. Again, closing this opening to 0.010 in. improved yarn appearance through better control of air.

Literature Cited

1. Bogdan, J. F., and Feng, I. Y. T., "Neps and How to Control Them," *Textile World* **102**: 5, 91–106 (May 1952).
2. Cheng, R., and Morton, W. E., "Control of Flat Strips in Carding," *J. Textile Inst.* **42**: 8, 442–455 (August 1951).

Reducing Waste at the Card

E. Allen Bentley

Swift Manufacturing Company, Columbus, Georgia

THIS paper is concerned with mill application of the North Carolina State College carding recommendations.

Research projects at the mill level often lead to difficulties, as management is inclined to think that such things as quality, cost, and efficiency should get first consideration. As a result of these difficulties, progress in the mill is not as rapid as that experienced in research laboratories and, in the majority of instances, results are not as good.

The carding waste study was tailor made for our mill. We had completed two years' work prior to the date of this project, setting up accurate standards for wastes of all types. One year of these two was spent in an intensive effort to reach the standards we had set. In the majority of cases we were successful. At the time we began the North Carolina State waste studies we felt that we had done everything in our knowledge to reduce waste and were, therefore, eager to try something that would put more cotton into the cloth instead of sending it to the waste house.

Serious work on this project began in the spring of 1954 and continued into that summer. During that time every effort was made to follow as closely as possible the settings and applications set forth by North Carolina State.

An interesting and valuable sidelight to this work or, for that matter, any research work on machinery was the discovery and correction of off-standard conditions. Often these conditions were known to exist, but there had never been time to investigate. This in itself is worth the time spent on a project of this nature.

The cotton to which this paper refers is Low Middling. The machinery organization prior to the card was as follows: The opening line consisted of five blending feeders to each feeding line, followed by an SRRL opener. The main cleaning line consisted of a #11 Condenser, #12 Opener, #11 Con-

denser, #12 Opener, #11 Condenser, and a Superior Cleaner.

The picker line consisted of a hopper feeder, Superior Cleaner, and Saco-Lowell hopper. There was a three-blade beater in the breaker section, a two-blade beater in the intermediate section, and a Kirschner beater in the finisher section. This picking line was possibly different from most mills because much stock-dyed cotton is processed on our machinery.

Before reaching the card, a cotton passes through 4 cleaning actions in the opening room and 4 in the picking room. This is a total of 8 cleaning actions, plus the auxiliary equipment such as blending feeders and hoppers. In each case these give a little better opening and blending of the fiber.

The cards used in the experiments described in this paper were Saco-Lowell and were fed a 17-oz lap. They were run at a production rate of 20¾ lb per hr. The licker-in speed was 790 rpm, and the main cylinder speed was 168 rpm. Each card was equipped with a continuous stripper. Cards were not equipped with a vacuum stripping system and were hand stripped once every 24 hr. The grinding and setting cycle was once every 21 operating days, at which time the flats, cylinders, and doffers were lightly ground and completely reset. Fourteen-inch cans were used. All cards were equipped with ball-bearing comb boxes. Fillet wire used was 100's on the cylinder and 110's on the doffer and flats.

Any work of this nature is limited by undesirable factors present in any card room, such as imperfect card alignment, floors which are not level and solid, and temperatures which are difficult to control exactly. In order to remove as many of these variables as possible, it was decided to start at the ground and build up, correcting off-standard conditions along the way. An example of this was the use of rubber pads placed at each point where the card comes in contact with the floor. These pads absorbed most of the shock and vibration and proved to be one of the most important parts of the entire project. They helped immensely in allowing us to obtain necessary settings and aided greatly in experimenting with the ideal settings as recommended by North Carolina State.

One of the main problems encountered was development of a practical drive from the cylinders to the flats. Several installations were tried before a drive was discovered that looked good on the card and performed well. This drive originated at the cylinder shaft, which is the same place the old drive originated except that the original pulley was removed. From the cylinder shaft the drive goes to an idler shaft which is located just above the cylinder. On this shaft there is a flat face pulley and a V-belt pulley. The flat pulley is the driven pulley and the V-belt pulley is the driver. From the idler shaft the drive goes directly to a V-pulley located on the worm-gear shaft. The drive from the worm-gear shaft to the flats is conventional. The new

TABLE I. Manufacturing Organization Carding

	N.C.S.	Swift #1	Swift #2	Swift Regular
Make	S.L.*	S.L.	S.L.	S.L.
Wire size				
Licker-in (P/s in.†)	32	32	32	32
Cylinder	100	100	100	100
Doffer and flats	110	110	110	110
Speeds				
Licker-in	800	800	800	800
Cylinder	165	168	168	168
Flats (in./min)	0.40	0.75	0.75	3
Settings (M/in.)				
Feed plate to licker-in	12	12	12	10
Mote knife to licker-in:				
Top	7	7	10	12
Bottom	7	7	10	10
Top mote knife to feed plate (in.)	1	0.75	1	
Bottom mote knife to bars (in.)	⅞	0.50	0.50	1¼
Top edge of back plate to flats	10			
Mote knife angle	30°	30°	30°	30°
Licker-in screen to licker-in:				
Back, middle, and front	10	22	34	34
Licker-in to cylinder	7	7	7	7
Backknife plate to cylinder:				
Top	22	22	34	29
Bottom	68	68	34	34
Flats to cylinder:				
Back and intermediate	7	7	10	10
Intermediate	9	9	10	10
Intermediate	10	10	10	10
Front	12	12	10	10
Continuous stripper (in.)		1¼	1¼	1¼
Flat stripping comb to flats	15	15	15	22
Front knife plate to cylinder:				
Top and bottom	34	34	34	34
Doffer to cylinder	5	5	5	7
Doffer comb to doffer	17	17	22	22
Cylinder screen to cylinder:				
Back	29	29	29	17
Center	68	68	34	34
Front	187	187	68	64
Type licker-in screen and cylinder screen	Bar	Perf.‡	Perf.‡	Perf.‡

* Saco-Lowell.
† Points per square inch.
‡ Perforations.

flat speed is ¾ in. per min as compared to 4/10 in. recommended originally. Flat speeds have actually been cut from 3 in. to ¾ in. per min, or 75%. From observations and discussions with card maintenance men, it was discovered that the cards performed as satisfactorily as ever. The cost of material and labor for these changes amounted to about $15 per card.

Table I shows the settings recommended by North Carolina State and those finally adopted. This table shows four settings: North Carolina State recommended setting, Swift setting #1, Swift setting #2, and a column headed "Swift Regular," which was the setting used prior to the tests. The Swift #2 column contains the settings which were finally adopted. It should be noted that the Swift #2 mote knife-to-licker-in setting is different from the North Carolina State recommendation. Better results were obtained from a 10 × 10 setting than from those obtained with the 7 × 7 setting as recommended. Better results were also obtained from a mote knife-to-bar setting of ½ in. instead of the recommended ⅞ in. It was found that the regular position of the licker-in screen still gave the best result. A back plate-to-cylinder setting of 34 × 34 was found to be better than the recommended setting of 22 × 68. Flats-to-cylinder were set at 10 all the way, as it was felt that a setting of 7 could not be maintained in production. The doffer comb-to-doffer setting of 22 was found to detach the web more efficiently than the recommended setting of 17. This was probably due to the high rate of production and high doffer speed on these cards. The cylinder screen-to-cylinder settings also differed from the North Carolina State settings.

Table II is a tabulation of the results obtained at the Swift Manufacturing Co. as compared to those obtained by North Carolina State. In this table it can be seen that Swift flat-waste percentage was 1.15 while North Carolina State's percentage was 0.66. Fly percentage was 1.14 compared to North Carolina State's percentage of 1.57. It should be noted that Swift fly waste from original settings was reduced from 2.01 to 1.14% and that flat strips were reduced from 1.74 to 1.15%. Scavenger waste and doffer waste remained approximately the same. Cylinder waste was reduced from 0.25 to 0.18%.

With these new settings and slow flat speeds, 97.19% of the net weight fed to the card is delivered in the sliver. This represents a gain of 1.54% from 95.65% delivered with the old settings. Although this figure does not sound large, it takes on added importance when calculated on a basis of 400,000 lb per week fed to the cards. What this amounts to in a period of 1 year may be easily calculated.

These tests were made on 10 cards. In view of the excellent results obtained with the new settings, the decision was made to modify 100 cards with these settings. Exhaustive tests have been made on quality, and it has been found that nep counts are within the tolerance accepted and are running somewhat below established standards. Yarn evenness

TABLE II. Card Waste Tests

	Sliver	Cylinder	Doffer	Flats	Fly	Scavenger	Total (%)	Loss or Gain
N.C.S.—Swift settings	95.84	0.28	0.10	1.78	1.90	0.10	100.00	
N.C.S.—N.C.S. settings	97.28	0.29	0.12	0.66	1.57	0.08	100.00	
Swift #1 settings	96.48	0.22	0.31	1.38	1.39	0.05	99.83	−0.17
	96.12	0.16	0.28	1.22	1.40	0.05	99.23	−0.77
	97.82	0.16	0.16	1.12	1.01	0.05	100.32	+0.32
	96.41	0.47	0.21	1.18	1.45	0.29	100.01	+0.01
Average	96.71	0.25	0.24	1.23	1.31	0.11	99.85	−0.15
Swift #2 settings	97.18	0.16	0.33	1.10	1.33	0.05	100.15	+0.15
	96.61	0.27	0.35	1.17	0.93	0.05	99.38	−0.62
	97.77	0.117	0.127	1.17	1.17	0.053	100.41	+0.41
Average	97.19	0.18	0.27	1.15	1.14	0.051	99.98	−0.02
Swift regular	96.40	0.09	0.23	1.71	1.64	0.05	100.12	+0.12
	94.89	0.40	0.32	1.77	2.38	0.06	99.82	−0.18
Average	95.65	0.25	0.28	1.74	2.01	0.06	99.99	−0.01

variation is running at 87/100%, which is equal to or better than normal production. The break factor is virtually unchanged, ranging around 1950.

Quality

	N.C.S.	Swift #1	Swift #2	Swift Regular
Neps/grain		10.6	9.86	12.0
Grains/strip		52.07	36.99	
Shirley fly from licker-in				
Good lint (%)		23.6	21.20	27.4
Trash (%)		68.2	70.8	66.4
Cage (%)		8.2	8.0	6.2

It should be pointed out that cotton costs approximately 35¢ per pound as against 6¢ per pound for fly and 18½¢ per pound for strips. A saving of approximately $35,000 per year is the expected result of converting 100 cards. At Swift Manufacturing Co., plans are being made to go still further in other card rooms, now that this phase of the work has been completed. New tests will be made on different types of work which are at present running in these rooms.

While in some cases results that we obtained were not as good as the North Carolina State results, in other cases we were able to better their results. There is an overall percentage difference of only 8/1000 between the Swift settings and the North Carolina State settings. This difference is in favor of the mill.

The results are very satisfying. Yarn really looks cleaner, and there are no detrimental effects which can be found. We are sure that the management of our mill will be well satisfied with the resultant savings.

In conclusion, I would like to gratefully acknowledge the assistance given to me from the North Carolina State College and from Mr. George H. Bass, Manager of the Standards Department at Swift Manufacturing Co., under whose direct guidance this project has been brought to a successful ending.

A Method of Reducing Card Waste

Hugh M. Brown, J. L. Thompson, and J. S. Graham

School of Textiles, Clemson College, Clemson, South Carolina

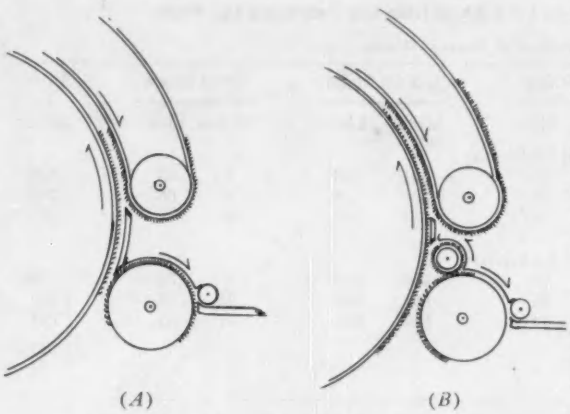
THIS is a progress report on a very preliminary card study undertaken at the Clemson College School of Textiles. The project grew out of the work reported last year on reversing the direction of running card flats. In that study it was noted that running the flats in reverse removes many pieces of seed coat, trash, and tight tufts of unopened cotton, all of which in normal operation go on through the card. More of such trash, etc., can be brought out by running the flats faster in the reversed direction, but, of course, this also increases the white waste in the flat strip.

A plan was proposed in which the flats were to be run in two sections: one, a very short section at the rear that would be run at a relatively high rate, and the other, the main section, to be run very slowly. The short section would bring out large amounts of the trash and seed coats as well as much lint, which would then be put back with the ingoing stock to be reworked by the licker-in. It was hoped that the regular flats never receiving the large pieces of trash, seed coats, etc., might make less neps and certainly less waste.

To divide the flat section in two parts would involve considerable change in the card construction, and it was thought that a single, properly clothed cylinder mounted between the licker-in and the regular flat section might serve the same purpose as a separate flat section. The added cylinder would be somewhat in the nature of a worker, but it would be run in the opposite direction.

In considering the problem of stripping this cylinder and returning the strippings to the stock, it was decided, in the first form, to let the waste-removal cylinder be stripped by the licker-in itself. (See Figure 1.)

The mounting of the waste-removal cylinder is very straightforward, and the present licker-in cover



(*A*) (*B*)

Fig. 1. (*A*) Regular card and (*B*) card with waste-removal cylinder.

is replaced with one to cover both the licker-in and added cylinder. Provision is made for settings with respect to both the carding cylinder and the licker-in. A Plexiglas window in the housing permits observation of both the waste-removal cylinder and the licker-in, to see the amount of waste and cotton being returned to the feed plate.

Studies were made with two different cottons. All wastes and the card sliver were carefully weighed and analyzed by the Shirley Analyzer. For each type of waste, the motes as per cent of the total motes and the lint in the waste as per cent of the total lint fed were determined. Nep counts were also made.

In Table I the motes and lint in each type of waste using the waste-removal cylinder are shown as percentages of the corresponding values for the card operating normally, except that flats were run in reverse direction. Thus all figures are relative. The results did not turn out as expected. There was no significant reduction in neps and instead of an increase in motes removed there was a slight decrease; however, there was a surprising reduction in white waste in the mote box, as high as 60 to 70%, and a considerable reduction in total lint loss.

Two questions arose: First, even though there was a definite reduction of large pieces of trash in the flat strip, why were there not more motes in the licker-in waste? Second, since the waste-removal cylinder does not act on the cotton until it has passed the licker-in, how can it reduce the loss of lint through the mote knives and licker-in screen?

It was thought the most logical answer to these questions was that the addition of the waste cylinder had in some way altered the air currents around the licker-in. Measurements showed that the air pressure in the mote box without the added cylinder was 0.004 in. of water and that the use of the trash-removal cylinder lowered the pressure to 0.0033 in. In view of the openings in the walls of the mote box, it seemed surprising that there should be any pressure under the licker-in. The mote box was then sealed with tape and an airtight partition placed across the opening between the chamber under the cylinder and the chamber under the licker-in. Operating the card without the added cylinder produced a pressure of 0.0047 under the cylinder and a vacuum of −0.032 to −0.04 under the licker-in. When the partition was removed the pressure under the licker-in rose to 0.0033. This shows that in regular

TABLE I. Effect of Trash-Removal Cylinder on Card Waste

RPM of Trash-Removal Cylinder	Production (lb/hr)	Setting	Per Cent of Normal Waste									
			Neps in Web	Motes & Fly		Flat Strips		C & D Strips*		Total Waste		Motes in Sliver
				Motes	Lint	Motes	Lint	Motes	Lint	Motes	Lint	
				Lap *A* 1% Motes								
310	6.5	0.012	135	97	27	112	97	153	108	105	68	89
310	15.5	0.012	82	81	33	106	106	147	142	95	83	109
310	6.5	0.007	135	94	50	91	92	192	122	97	78	106
310	15.5	0.007	71	70	48	103	97	158	180	89	89	120
				Lap *B* 1.5% Motes								
310	6.5	0.007	94	86	53	94	89	349	121	98	85	107
310	14.5	0.007	90	87	61	98	80	143	107	97	85	107
540	6.5	0.007	99	93	35	95	82	262	132	99	78	102
540	14.5	0.007	101	92	44	97	82	142	96	99	80	102

* Cylinder and doffer.

TABLE II. Effect of Waste Removal Cylinder on Card Waste from Lap Containing 5% Waste *

Pressure in Mote Box (in.)	Per Cent of Normal Waste									
	Neps in Web	Motes & Fly		Flat Strips		C & D† Strips		Total Waste		Motes in Sliver
		Motes	Lint	Motes	Lint	Motes	Lint	Motes	Lint	
				460-RPM Licker-In						
0.0400	102	88	6	121	83	181	88	95	65	178
0.0033	109	93	41	110	74	126	79	97	66	152
0.0025	103	92	53	106	74	174	97	96	73	165
				760-RPM Licker-In						
0.0023	164	100	44	76	98	144	113	97	75	156
0.0023	170	99	53	85	86	149	104	98	73	149
0.0630	143	100	30	77	94	139	104	97	64	152

* 620-rpm cylinder set 0.007 in. 8.5 lb/hr production.
† Cylinder and doffer.

card operation air currents created by the cylinder move into the mote box and are drawn up through the mote knives and licker-in screen. This air must be carried under the backknife plate along with the cotton carried by the cylinder. In other words, the cotton-covered cylinder wipes air under the knife plate and thereby carries it away from the licker-in, tending to exhaust the air from the mote box, which explains the vacuum produced when the mote box is sealed. Pressure measurements showed this action to be greater when the cylinder carried cotton than when running empty.

When the waste cylinder is added a much narrower backknife plate must be used, and it was thought that possibly this narrower plate might offer less resistance to the passage of air under it and thus enable more air to be brought through the licker-in screen and mote knives than is the case in the normal operation with a wide backknife plate.

To study the problem further it was arranged to vary the pressure in the mote box. An especially trashy cotton was carded with and without the waste-removal cylinder, using two licker-in speeds at two different pressures in the mote box.

For each licker-in speed, Table II shows the results for three runs with, and three runs without, the waste-removal cylinder. The motes and lint in each type of waste produced when using the waste cylinder are shown as percentages of the corresponding values given without the device. Several effects should be noted:

1. For the normal licker-in speed there was:

(*a*) An increase in motes in the flat strip, in the cylinder strip, and in the sliver, but only a small reduction of motes in the licker-in waste.

(*b*) A large reduction in lint in the licker-in waste and a considerable reduction of lint in the flat strip and cylinder strip, and in total lint loss.

(*c*) Lower lint loss in the mote box with higher mote-box pressure.

(*d*) A slightly higher nep count.

2. For the high-speed licker-in there were:

(*a*) More motes in the cylinder strip and sliver; no change in motes for the licker-in waste; and less

TABLE III. Effect of Pressure in Mote Box on Card Waste from Lap Containing 5% Waste *

Pressure in Mote Box (in.)	Per Cent of Normal Waste									
	Neps in Web	Motes & Fly		Flat Strips		C & D† Strips		Total Waste		Motes in Sliver
		Motes	Lint	Motes	Lint	Motes	Lint	Motes	Lint	
				460-RPM Licker-In						
0.04000	84	98	36	106	79	126	97	99.8	71	104
				760-RPM Licker-In						
0.06300	107	100	29	99	117	104	109	99.5	75	110

* Production: 8.5 lb/hr.
† Cylinder and doffer.

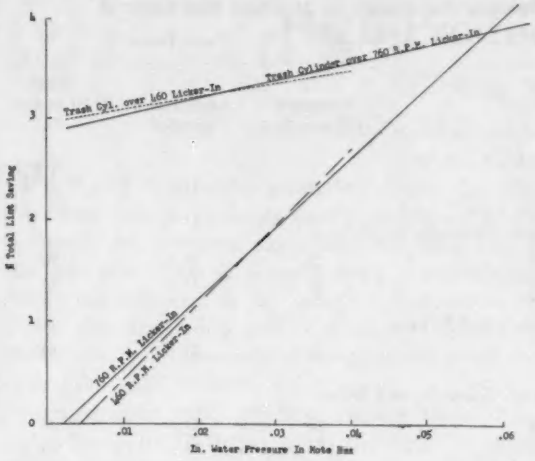

Trash Cyl. over 460 Licker-In
Trash Cylinder over 760 R.P.M. Licker-In
760 R.P.M. Licker-In
460 R.P.M. Licker-In
% Total Lint Saving
In. Water Pressure In Mote Box

Fig. 2. Lint saving for whole card by use of waste cylinder and air pressure in mote box.

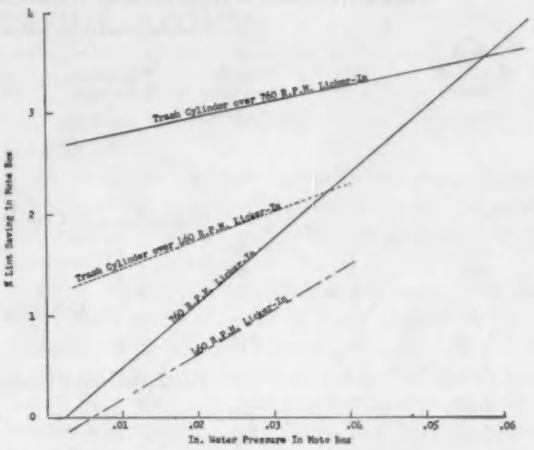

Trash Cylinder over 760 R.P.M. Licker-In
Trash Cylinder over 460 R.P.M. Licker-In
760 R.P.M. Licker-In
460 R.P.M. Licker-In
% Lint Saving in Mote Box
In. Water Pressure In Mote Box

Fig. 3. Lint saving in mote box by use of waste cylinder and air pressure in mote box.

motes in the flat strip, giving a very slight decrease in total motes removed by the card.

(*b*) A considerable reduction of lint in all forms of waste except cylinder strip.

(*c*) A large increase in neps.

3. The flat strip was free of large pieces of trash and unopened cotton.

If using the waste cylinder resulted in different air currents through the licker-in screen and mote knives, it was thought that using air pressures under the licker-in might produce somewhat the same results. This was tried, and the effects of adding only air pressure under the licker-in, making no other changes in the card, are shown in Table III. It is noted that for the normal-speed licker-in there was a large reduction in lint in the licker-in waste and some reduction in all the wastes, giving a considerable total lint saving. The total saving in lint was as great as that for the waste-removal cylinder used without added pressure, and there was practically no impairment of mote removal.

For the high-speed licker-in the use of added mote-box pressure gave as good mote removal and total lint saving as was given by the waste-removal cylinder, and in the licker-in waste the reduction of lint loss was greater than that obtained with the waste cylinder. Also, the use of air pressure in the mote box did not seem to give quite as many neps as the operation using the waste cylinder. On the other hand, addition of air pressure alone does not reduce the amount of larger trash reaching the flats.

Thus it is seen that a lint saving can be had by use of either the waste-removal cylinder or by increased pressure in the mote box. Possibly the improvement gained by using the waste cylinder is mainly due to resultant changes in air currents around the licker-in. It is believed that these changes in air flow may be caused by the altered backknife plate, and this point is to be given more study. In Figure 2 the lint saving for the whole card is plotted against the mote-box pressure.

Because of the relative worthlessness of licker-in waste, the lint saving here is the most important; and Figure 3 shows the per cent savings by use of air pressure and by the waste cylinder.

As is usually the case, savings cost something. The waste tests showed that the above methods slightly increased the motes in the sliver, and spinning tests were run to determine whether the final yarn is impaired by the additional trash in the sliver or by possible fiber damage caused by the waste-reduction methods. The yarns were tested for evenness, strength, and grade, the results being shown in Tables IV and V. Several effects of using the waste-removal cylinder are evident.

1. For the normal-speed licker-in at two different production rates cotton *B* showed no appreciable change in yarn strength, evenness, or grade, due to use of the waste cylinder. It is believed that the additional motes in the sliver are of such character

TABLE IV. Effect of Trash-Removal Cylinder on Spinning Test Results for 36's Yarn from Cotton *B*

Speed of Added Cylinder (rpm)	Carding Performance			Yarn Tests		
	Neps in Card Web (neps/100 sq in.)	Cleaning Efficiency (%)	Lint Savings (%)	Evenness (% uneven)	Appearance (grade)	Skein Strength (lb)
	No Added Cylinder, 6.5 lb/hr					
	54	61		21	D+	51
	Trash-Removal Cylinder over Licker-In, 6.5 lb/hr					
310	50	62	0.9	22	D+	50
540	53	56	1.3	22	D+	51
	No Added Cylinder, 14.5 lb/hr					
	158	49		23	D	48
	Trash-Removal Cylinder over Licker-In, 14.5 lb/hr					
310	142	50	0.6	22	D	48
540	160	48	0.8	23	D	46

TABLE V. Effect of Trash-Removal Cylinder and Pressure in Mote Box on Spinning Tests Results for 36's Yarn from Cotton *C*

Carding Set-Up		Carding Performance			Yarn Tests		
Licker-In Speed (rpm)	Mote-Box Pressure (in. water)	Neps in Card Web (neps/100 sq in.)	Cleaning Efficiency (%)	Lint Savings (%)	Evenness (% uneven)	Appearance (grade)	Skein Strength (lb)
		No Added Cylinder					
460	0.0025	63	94		21	C	61.2
460	0.0400	58	94	2.7	19	C+	64.2
760	0.0025	46	95		19	C+	63.0
760	0.0630	55	95	4.3	20	C	62.3
		Trash-Removal Cylinder over Licker-In					
460	0.0025	60	90	2.7	22	C	61.2
460	0.0400	51	90	3.5	20	C	61.4
760	0.0023	74	93	2.9	22	D+	58.2
760	0.0630	79	93	4.0	21	D+	59.0

that most of them may be lost during later phases of processing.

2. For cotton *C*, at normal mote-box pressure and licker-in speed, the use of the waste cylinder did not impair the yarn.

3. At higher pressure under the licker-in run at normal speed the waste cylinder seemed to slightly reduce yarn strength, grade, and evenness.

4. With the high-speed licker-in at both air pressures the waste cylinder gave a small reduction in strength, grade, and evenness.

It is not thought that impairment of the sliver or yarn is inherent in the method. It is feared that the waste cylinder may have been run at too high a speed and that the type of clothing used may not have been best for the purpose so that there was impairment in some cases. In previous work where large trash, etc., was brought out by reversing the motion of the flats, the sliver was improved even when the flat strip was fed back in with the lap. It should be realized that this study has only begun. It is believed that at a very low cost a worth-while lint saving may be had without impairment of the sliver. There are many things yet to be tried, such as different speeds, settings, types of clothing, and arrangements of air flow and shape of housing.

High-Production Carding

S. H. Sherman

United States Rubber Company, Winnsboro, South Carolina

WE HAVE heard a great deal during the past four years about increasing card production. There seems to be, however, no widespread adoption of the practice. This is not surprising when one reviews the literature on the subject. Conclusions of those who have tried, and of some who appear to have little or no intention of trying it, range all the way from good to bad.

An oldtimer, who has been carding since 1899, says that 3 to 12 lb per hr is the limit for good carding [6]. On the other hand, work has been done at the School of Textiles, North Carolina State College, with productions as high as 55 lb per hr [7, 11].

Those who have tried higher card productions report a wide variety of test conditions and results. Licker-in speeds vary from 500 to 818 rpm [3, 5]. Productions range from 6½ to 25½ lb per hr [5, 13].

Nep Counts

Six mills tested higher licker-in speeds. Five noted a *decrease* in nep count [3, 8]. Seven mills tested higher licker-in, doffer, and cylinder speeds. Most report an *increase* in nep count [4]. Ten mills tested higher licker-in speeds and increased production. The consensus of opinion was a slight *improvement* in nep count [2].

A test run of 9 million lb at as much as 40% increased production rate showed neps *reduced* as much as 10 to 12% [9]. A comparison of 5 lb per hr versus 15 lb per hr showed the lower rate to give better cleaning efficiency, *fewer* neps, and less trash in the card web [12].

Mill Problems

In a survey of 150 mills made by North Carolina State College, 32 had tried high production carding. Twenty-one mills reported benefits through increased production, less neps, or both. The reasons many have failed appeared to be: (1) by not applying *all* the changes recommended; (2) by giving up too easily [11].

In 1952, we decided that with so much smoke there must be some fire and that we would do some experimenting of our own. We realized there were problems.

E. A. Bentley, at the Cotton Research Clinic in 1952 [10], outlined some of them as follows: (1) high doffer speeds made piecing up difficult. (2) Doffer combs gave trouble at the higher speeds because they were not true. They had to be overhauled and milled. (3) Comb-box bearings gave trouble at the higher speeds. (4) Feed rolls had to be true and properly weighted to prevent plucking. (5) Better grinding and more accurate settings were necessary.

To avoid troubles with high doffer, comb, and comb-box speeds, we added another coiler to our card and split the web by dropping a steel ribbon down between the doffer and cylinder (Figure 1). This was reported in [1]. The article claims double production because two 27-grain slivers are made instead of one.

In order to double production without changing the speed of any part, we added the standard attachment to our card for feeding two laps (Figure 2). With this attachment two 15-oz laps were fed into the card and two 50-grain slivers were delivered at the front.

Bunch plucking at the licker-in was an immediate problem. To overcome this, we replaced the regular feed roll with a special feed roll having deeper flutes. We also added 18 lb of weight to each side of the roll. To further insure freedom from plucking, we replaced the top mote knife with a Saco-Lowell control roll (Figure 3).

Other changes were: (1) the licker-in speed was increased to 650 rpm. Higher speeds than this caused too much white cotton in the licker-in fly; (2) the cylinder speed was increased to 203 rpm. but the production gear was changed to maintain the original feed roll and doffer speeds; (3) the flat pulley was changed to maintain our regular top flat speed; (4) perforated screens were installed to eliminate air turbulence created by the higher cylinder speed.

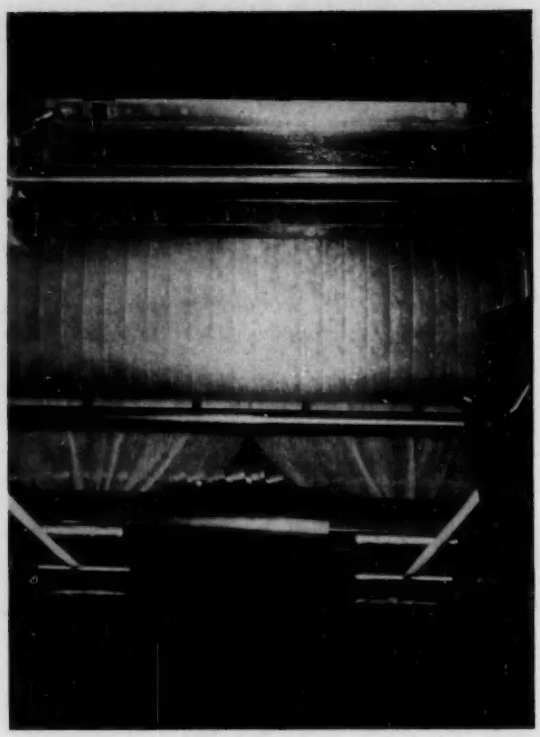


Fig. 1.

Fig. 2.

Total cost of these changes was estimated at about $1100 installed.

Two changes in settings were necessary. At first the feed plate was set 0.015 in. from the licker-in. Tests showed this was too close and was breaking fibers. Experiments showed 0.045 in. from feed plate to licker-in and 0.007 in. from control roll to licker-in corrected fiber breakage problems. These settings allow the cotton to be released by the feed roll before it is injured by the licker-in. The control roll holds the cotton until the bunches are divided and distributed over the surfaces of the licker-in and cylinder.

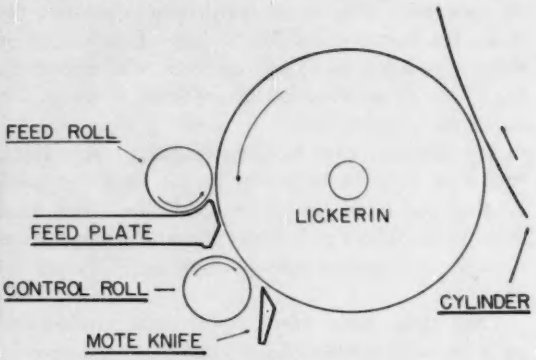


Fig. 3. Saco-Lowell control roll.

Fig. 4.

TABLE I. Results Obtained Using Middling 1-in. Cotton

Hours after Grinding	Production: 9.6 lb/hr (lb)	Neps per Grain	Production: 19.2 lb/hr (lb)	Neps per Grain
24	230	5.57	480	2.81
48	460	7.51	960	4.43
72	690	9.56	1440	5.47
96	920	8.37	1920	6.23
120	1150	9.72	2400	6.82
144	1380	8.45	2880	3.90
168	1610	7.79	3360	6.69
192	1840	7.41	3840	7.04
216	2070	9.62	4320	5.90
240	2300	8.95	4800	7.63
264	2530	7.05	5280	6.33
288	2760	7.31	5760	5.65
312	2990	9.58	6240	5.96
	Ave.	8.22	Ave.	5.76

TABLE II. Results Obtained Using Card Modifications

Evenness

Uster Tests	Regular (%)	Experimental (%)
Card sliver	1.96	1.62 (full can)
1st drawing	3.58	3.24 (full can)
2nd drawing	3.70	3.67 (full can)
Roving	6.06	5.99 (4 full bobbins)
Yarn	12.80	13.60 (4 full bobbins)

Yarn Strength

Licker-In to Feed Roll Setting (in.)	Regular		Experimental	
	Yarn Size	Break Factor	Yarn Size	Break Factor
0.015	15.27	2116	16.26	1950
0.045	16.39	1970	17.07	2026

Waste

Type	Regular Card (%)	Experimental Card (%)
Flat waste	2.75	1.80
Other waste	1.49	1.00
Total	4.24	2.80

Later, the lap feeding device was modified to avoid using extra floor space. The second lap was fed from a roll placed above the regular lap roll and supported by the rods which normally hold the lap waiting to be creeled (Figure 4).

Results

These modifications gave the following results using Middling 1-in. cotton:

1. Production was doubled (Table I).

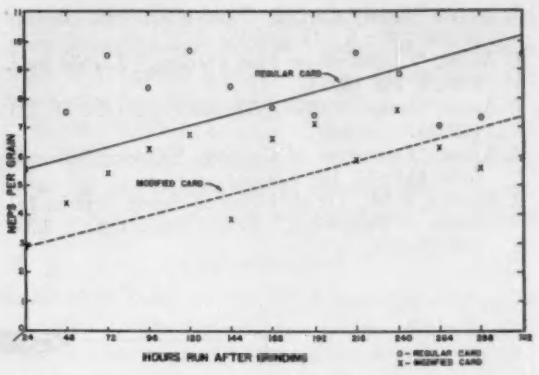


Fig. 5. A graphical presentation of the data in Table I.

2. Neps were reduced 30% (Table I and Figure 5).

3. Sliver was more even, probably due in part to the extra doubling at the back of the card (Table II).

4. Yarn had equal or better strength (Table II).

5. Waste was reduced. The experimental card made 34% less top flat waste. Fly was somewhat less and can be adjusted (Table II).

Summary

Advantages achieved by these changes were:

1. Higher production.

2. Lower cost: (*a*) less floor space for same production; (*b*) less grinding per pound; (*c*) less waste.

3. Improved quality: (*a*) fewer neps; (*b*) more even sliver.

Acknowledgment

The author wishes to thank Elvin H. Bond, Supervisor of Processing Development, Textile Division, United States Rubber Company, who did the actual experimental work.

Literature Cited

1. Anon., "Split Web Doubles Card Production," *Textile Inds.* **116**: 2, 133 (1952).
2. Anon., "Carding and Spinning Practices," *Textile Inds.* **116**: 6, 149 (1952).
3. Anon., "Alabama Carding Spinning Meet," *Textile Inds.* **116**: 7, 125 (1952).
4. Anon., "Discussion of Carding Practices," *Textile Inds.* **117**: 6, 175 (1953).

5. Anon., "Timely Carding Topics Ga. TOE," *Textile World* **103**: 6, 135 (1953).
6. Anon., "Comments on Fast Carding," *Textile Inds.* **117**: 7, 162 (1953).
7. Anon., "News in Brief," *Textile Inds.* **117**: 11, 121 (1953).
8. Anon., "Discussion of Carding, Spinning," *Textile Inds.* **117**: 12, 135 (1953).
9. Bentley, E. A., "High Licker-in Speed Permits Increase in Production," *Textile Inds.* **116**: 5, 100–103 (1952).
10. Bentley, E. A., "We're Carding at 25 Pounds per Hour," *Textile World* **112**: 5, 107 (1952).
11. Newell, William A., "Mill Experience with Speeded-up Carding," National Cotton Council of America, *Cotton Research Clinic,* 48–56 (1953).
12. Simmons, R. O., "Cotton Cleaning in Mills," National Cotton Council of America, *Cotton Research Clinic,* 10 (1951).
13. Thomas, P. M., "What Happens When You Speed-up Cotton Cards," *Textile World* **102**: 10, 94 (1952).

Commercial Spinning Tests on Pima S-1

Burt Johnson

National Cotton Council of America

Introduction

Egyptian-grown Karnak cotton has in recent years dominated the extra-long staple market because it furnishes a sure supply of quality fiber. American growers have sought to match Karnak, both as to lint quality and efficiency of production. A number of American-Egyptian strains, Pima, S × P, Earlipima, Amsak, and Pima 32, have followed each other in the market. Each strain was generally better than the preceding one, both in yields and quality, but none of them equaled Karnak in both yield and fiber properties. Amsak and Pima 32, except for neppiness, were essentially equal to Karnak in fiber quality, but their yields were still relatively low.

A new cotton, Pima S-1, is now being released to growers. In 1953 about 2500 acres were grown. The 1954 American-Egyptian crop in Arizona is about 16,000 acres, of which about 14,000 acres were planted to Pima S-1. These 14,000 acres are expected to produce 15,000 bales. Texas and New Mexico combined planted another 16,000 acres of American-Egyptians, of which only a small part is Pima S-1 produced on an experimental basis.

Pima S-1 (known during its developmental phases as 126-S-1 and as Dwarf Pima) is a complex cross of Pima, Tanguis, and Upland strains. It seems to be well adapted to the low-lying hot valleys of Arizona; it may not be fully suitable to the higher elevations of New Mexico and Texas, where *Verticillium* wilt offers a threat. Pima S-1 is not, because of the admixture of Upland "blood," as resistant to or tolerant of *Verticillium* as are the older Pima strains, especially in adverse seasons. It is believed the extensive experimental plantings of 1954 in Texas and New Mexico will rather definitely determine the adaptability of this new cotton to these states.

On November 1, 1954, the U. S. Department of Agriculture estimated that 31,800 acres of American-Egyptians will produce 29,200 bales. This means a yield of 440 lb per acre, exactly 100 lb greater than the 1953 acre-yield and 96 lb more than the average yield for 1943–1952. Remembering that almost half the acreage is still in Pima 32, the large increase in yield in 1954 indicates farmers are doing a better job of growing American-Egyptians, or the large acreage of Pima S-1 has increased the yields, or the weather is ideal, or all three. There is a concerted effort to improve the culture of these cottons so as to reduce their cost of production, and this program may now be yielding results.

When Pima S-1 was still known as 126-S-1 and as Dwarf Pima, and then only to a very few people, it was subjected to numerous small agronomic, fiber,

and spinning tests, and during the past couple of years to limited commercial spinning tests. Practically all these tests showed that the then-to-be Pima S-1 was superior to all its American-Egyptian predecessors in yield, probable adaptability of the plant to machine harvesting, earliness of the crop, ease of picking, cost of ginning, and quality of yarns made from it. Not only did it surpass the older American-grown extra-long staple cottons, but, except possibly for neps, it fully equaled in these small tests the quality of products made of Karnak, the standard in extra-long staple markets.

Pima S-1's fiber was studied carefully. In general, the extra-long staples are thought of as being 1½-in. staple cottons, with certain small parts of each crop being 1/16 in. shorter and longer than the average staple. These cottons in their better qualities have Micronaire finenesses of 3.0 to 3.2. Because of their fineness and length, they have to be processed slowly and gently if excessive nepping is to be avoided. Finally, these cottons are very strong, the average strength being perhaps 100,000 ±3,000 psi. The fiber properties of Pima S-1 were judged against those criteria.

Pima S-1 is about a 1 1/16-in. cotton. The Fibrograph and Suter-Webb measurements in general confirm that this is about the correct staple for the cotton. A remarkable thing about the length of Pima S-1 is its high mean length in relation to its own staple or to the staple of such a cotton as Karnak. This indicates a high length uniformity, or "good body" as the classer would say.

Pima S-1 is coarser according to Micronaire readings than are the present commercial strains of extra-long staples. A moderate increase in coarseness is believed to be desirable. Although Pima S-1 has very strong fibers, it usually is thought of as being just slightly weaker than some of its competitors. On the other hand, it is easy to cite individual tests which show Pima S-1 as being stronger than other cottons. Only a few elongation data have been published, and these indicate Pima S-1 has measurably more elongation than Karnak and several strains of American-Egyptians.

Practically every spinning test to which the early crops of Pima S-1 were subjected showed Pima S-1 easily holding its own, despite its fiber properties being considered slightly below those of such cottons as Karnak. It is believed, based on studies on other cottons, that Pima S-1's high length uniformity and good strength assure high yarn strengths. Its coarse fiber is associated with lower nep counts than are customary for American-Egyptians.

It was decided, because of these promising and consistent results, to place the 1953 crop of Pima S-1 in as extensive a commercial spinning test as possible. The results of these tests comprise this report.

Experimental

Random bales of the 1953 commercial crop of Pima S-1 were classed, and on the basis of this classification were offered to various mills and laboratories for commercial spinning tests. Ten organizations including not fewer than 14 spinning plants participated in these tests. Each plant had available at least one bale of Pima S-1. Under similar conditions, each plant ran at least one type of control cotton, usually Karnak.

Each participating mill was permitted to select the constructions of yarns it wished to make and test. In most cases, the yarns made were standard commercial items made regularly and in large volume by the cooperator. Mills were urged to make each item in each of several ways to see if there were better ways to process Pima S-1 than by the usual methods used on the control cottons. No mills were able to carry out this suggestion, although one pilot plant did make each of its yarn counts according to various combinations of rates of carding, percentages of noils removed, drafts, and yarn twists. (Although some reference is made to these latter experiments in this paper, the details will be published separately by the cooperating laboratory.)

Control tests on yarns made of the mill's regular mix were run for each construction made from Pima S-1. In all cases, the mills reported their control cotton as being Karnak, except that one mill reported the control as being Sak. In addition, one cooperator ran a Pima 32 control as well as a Karnak control. Egyptian-grown Karnak is the standard for extra-long staples in American mills. Karnak is also the extra-long cotton most used, although for some purposes Peruvian Pima is preferred, and American-grown Pima is also used when price and supply make its use profitable.

A commercial spinning test cannot be as rigidly controlled, even within an individual mill, as can a well-conducted test in a small sample-spinning lab-

oratory. Most certainly, rigid control among 14 separate plants cannot be hoped for. No attempt was made to compare plants; therefore, control between them was not essential.

What the commercial test lacks in terms of ultimate control, it probably more than compensates for in values of wide range of products made under most diverse conditions of mill management, organization, and standards for quality of products. Thus a fairly accurate appraisal of the value and adaptability of the cotton to most mills is achieved in the commercial spinning test.

All cooperators, except one, were able to report their results on a standard form. This does not mean that all tests were conducted in the same manner. For example, yarn strengths were reported by pounds per skein break, as well as by various units for single-strand breaks. Another example is found in the case of nep counts, where it is certain that all technicians did not use the same standards.

Because of these facts, the most accurate means of evaluating Pima S-1 is to compare it only with Karnak in the same construction made in the same mill. Then, looking at all the results together, a general trend in the same direction for all yarns in all mills lends heavy support to findings in the individual cases observed.

The participating mills are coded in the text and results given in the next section.

Results

In general, as shown in Table I, the grades and staples of Pima S-1 and the control Karnak were very similar. The cotton classer would likely rate

TABLE I. Description of the Pima S-1 and Karnak Processed in Fourteen Spinning Plants

	Mill										
Fiber property	A	B	C-D-E	F	G*	H-I	J	K	L	M	N
Class											
Grade											
Karnak	—	—	FG–Ex	FG+⅜	FG–Ex	FG+¼	—	FG+¼	FG+¼	FG+⅛	—
Pima S-1	—	—	2	1	2	2	—	2	3	2	—
Staple (in.)											
Karnak	—	—	1 7/16	1 7/16	1 7/16	1 7/16	—	1 3/8	1 7/16	1 7/16	1 7/16
Pima S-1	—	—	1 13/32	1 7/16	1 7/16	1 3/8	—	1 7/16	1 7/16	1 7/16	1 7/16
Length											
Fibrograph											
Upper-half mean (in.)											
Karnak	—	—	—	—	—	1.43	—	—	1.25	—	—
Pima S-1	—	—	—	—	—	1.31	1.37	—	1.37	—	—
Mean (in.)											
Karnak	—	—	—	—	—	1.18	—	—	0.96	—	—
Pima S-1	—	—	—	—	—	1.12	1.17	—	1.16	—	—
Suter-Webb											
Upper quartile (in.)											
Karnak	—	—	1.37	—	—	1.35	—	—	1.42	—	—
Pima S-1	—	—	1.34	—	—	1.32	1.43	—	1.42	—	—
Mean (in.)											
Karnak	—	—	1.09	—	—	1.10	—	—	1.12	—	—
Pima S-1	—	—	1.16	—	—	1.08	1.23	—	1.22	—	—
Micronaire fineness											
Karnak	3.25	3.3	3.7	3.0	—	3.2	—	3.7	3.2	3.75	3.45
Pima S-1	3.35	3.4	4.0	3.6	—	3.2	3.4	3.6	3.9	3.95	3.95
Pressley strength (lb)											
Karnak	102,500	101,000	100,000	99,200	—	103,700	—	—	99,100	103,100	97,000
Pima S-1	99,000	101,000	100,000	100,000	—	103,700	98,300	—	96,300	100,900	106,900
Maturity (%)											
Karnak	—	—	84†	—	—	—	—	—	86	—	—
Pima S-1	—	—	79†	—	—	—	—	—	94	—	—

* Control cotton reported as Sak.
† Polarized light method.

TABLE II. Waste Factors for Pima S-1 and Karnak

Mill	Wastes: Total Opening and Picking — Karnak (%)	Total Opening and Picking — Pima S-1 (%)	Card — Karnak (%)	Card — Pima S-1 (%)	Noils Removed — Karnak (%)	Noils Removed — Pima S-1 (%)
A	2.14	2.00	7.94	6.94	16.45	10.15
B	1.20	1.22	5.04	4.47	10.92	7.66
C	2.54	3.67	5.89	5.41	15–20*	15–20*
D	—	—	—	—	15–20*	15–20*
E	—	—	—	—	15–20*	15–20*
F	2.20	—	6.99	—	15.99	16.00
G	2.58	2.25	10.06	7.36	15.60	11.90
H	1.60	1.70	6.40	6.70	18.10	14.70
I	2.27	2.13	7.82	7.48	15.40	16.49
J	2.10	1.50	11.30	9.00	16.00	16.00
K	1.79	—	6.95	—	17.50	—
L	2.71	2.04	8.13†	7.04†	15.18	15.18
M	1.91	1.81	7.83	6.03	17.00	17.00
N	1.39	1.91	7.80	6.10	14.50	14.50
Ave.‡	2.04	2.06	7.82	6.65	16.35	15.44

* Noils removed varied with yarn number spun.
† Mean for three rates of carding.
‡ Means of pairs of data only.

the spinning utility of No. 2 Pima S-1 and the Karnak used in these tests as being about equal, or possibly with a slight advantage in favor of Karnak.

The laboratory measurements of fiber properties do reveal differences which could well be reflected in the yarn properties. Previous studies showed that Pima S-1 has shorter upper-half mean and upper-quartile lengths than do the current commercial varieties of extra-long staple cottons. All cooperators, except L, making length measurements confirm this finding. But it had also been shown that Pima S-1, in spite of its generally shorter staple and low upper-half mean and upper-quartile lengths, has a high mean length, indicating a high degree of uniformity of fiber length. Uniformity of fiber length is associated positively with strength of many yarns, especially *fine* yarns. Again, with the exception of H and I, the cooperators confirmed that Pima S-1 has exceptional mean length, especially in view of its somewhat shy staple length.

All laboratories, with one exception, agreed that Pima S-1 has a Micronaire fineness equal to or coarser than Karnak. Past commercial strains of American-Egyptian cottons usually were finer than Karnak. These strains were also considered excessively neppy as compared to Karnak. Maturity is a factor influencing Micronaire readings. Only two cooperators, each using a different test method, reported maturities of the cottons. They were not in agreement.

The originators of Pima S-1 report it as being slightly lower in strength that both Pima 32 and some American-Egyptian strains. Cooperators were about equally divided as to whether or not the strength of the particular bales of Pima S-1 and Karnak used in these tests were superior one to the other. In general, the differences in strengths between the two cottons were within 3000 lb, a range often considered to be within the allowable tolerances in a lot of cotton.

In summary, the fiber properties of these lots of Pima S-1 and Karnak can be considered as being essentially equal, except that Pima S-1 has the higher Micronaire reading and the higher mean length.

Most mills, as shown in Table II, reported processing wastes. Average opening and picking wastes for the two cottons were equal. Under these circumstances, the expectation would be that in some mills the losses from Pima S-1 would exceed those from Karnak; in other mills, the opposite would prevail; while in still others, the losses from the two cottons would be about equal. The data confirm this expectation.

All mills, except H, showed less carding loss from Pima S-1 than from Karnak. This low loss from Pima S-1 may reflect the high mean length and Micronaire reading for this cotton. Low carding losses from Pima S-1 have been reported by other workers. Mill L carded at three rates for each construction spun; the data in Table II are the averages of card wastes for the three rates of carding at this mill.

The data on noil removal is less definite than for the other processing wastes. This is because several of the mills apparently set the comber for a certain percentage removal and then reported identical values corresponding to the machine settings. In those instances where the noils were weighed, regardless of the machine setting or settings, fewer noils were removed from Pima S-1 by 4 out of 6 of the mills reporting on this basis. Because of the two methods of reporting noils, the averages for noils in Table II should be accepted with marked reservation.

Table III gives the rates of carding and the number of neps associated with each rate of carding.

TABLE III. Neps in Card Web in Relation to Rate of Carding and Period after Stripping Card for Karnak and Pima S-1

Mill	Rate of Carding (lb/hr)	Neps in Card Web: 10 Min. after Stripping, Karnak	10 Min. after Stripping, Pima S-1	70 Min. after Stripping, Karnak	70 Min. after Stripping, Pima S-1
A	4.2	7.3	9.6	7.7	13.3
B	6.7	14.4	13.3	16.3	14.0
C	4.25	14.2	16.1	18.3	19.1
D	5.0	43.0	48.0	51.0	55.0
E	8.12	77.0	79.0	87.0	100.0
F	3.5	6.9	6.6	7.3	8.3
G	5.0	5.2	5.4	5.1	6.0
H	—	13.0	15.9	16.2	16.3
I	—	4.2	10.7	5.0	10.2
J	4.0	22.0	8.0	45.0	15.0
K	5.87	—	—	15.0	23.5
L	4.0	28.5	18.3	33.0	19.6
L	6.0	46.1	21.6	64.6	29.7
L	8.0	54.2	56.4	91.2	67.0
M	5.0	11.8	11.8	13.3	13.0
N	4.5	30.4	29.8	34.5	34.8
Ave.		25.2	23.4	31.9	27.8

In the past, American-Egyptian cottons have been neppier than Karnak and other Egyptian-grown extra-long staples. In this test, Pima S-1, on the average, equaled Karnak. Neps were counted at intervals of 10 min and 70 min following stripping. Although there were some increases in nepping with time after stripping, the increases for both cottons can perhaps be considered as moderate. Almost without exception, the faster the rate of carding, the larger the number of neps, regardless of the mill involved or the variety of cotton. It is obvious from the nep data that either (*a*) mills do not count and report neps in the same manner, or (*b*) processing from mill to mill is so varied that nep formation is affected, or (*c*) the two causes occur and do not cancel each other.

The fact the averages show fewer neps for Pima S-1 must be examined in light of the number of cases in which this cotton produced the fewer neps. Of 30 pairs of nep counts, only 11 showed fewer for Pima S-1, and some of these only by a very small margin. On the average, then, mills can expect to have slightly more to many more neps when processing Pima S-1 as compared to Karnak.

The expectation that the higher Micronaire reading for Pima S-1 would reduce neps is not well founded according to these data. It is possible Karnak is handled more gently and with less machining at the gin than is Pima S-1, and that this difference in treatment at the gin accounts for the higher nep count for Pima S-1, and that Pima S-1 inherently is not excessively neppy. The fact remains, though, that in these commercial spinning tests of cotton ginned in commercial plants Pima S-1 is likely to be neppier than Karnak processed by Egyptian ginning methods.

Pima S-1, as shown in Table IV, was about the equal of Karnak in ends down while spinning a wide range of yarn numbers. The values given should not be considered comparable from mill to mill as it is apparent mills reported ends down on various bases. As is well known, evaluation of cotton in terms of ends down is difficult. A test as limited in numbers of spindle hours studied as this test is probably does not give a complete picture of this phase of spinning efficiency. On the basis of the data available, it seems Pima S-1, especially after mill adjustments are made, will spin without undue trouble. A few mills reported Pima S-1 had a tendency to lap up but that adjustments in humidity overcame the difficulty.

All cooperating mills, except one, reported on single yarn strengths (Table V). Although Pima S-1 has a slightly shorter, weaker, and somewhat coarser fiber, it made yarns in a wide range of numbers and twists fully as strong as those made of Karnak. The average increase of 14% in strength of Pima S-1 yarns appears significant in

TABLE IV. Ends Down for Karnak and Pima S-1 in Relation to Yarn Number Spun

Mill	Nominal Yarn Number	Ends Down: Karnak	Ends Down: Pima S-1
A	90	15.2	22.7
A	100	38.5	25.5
B	16	12.5	8.9
B	26	12.5	8.9
C	8	37.0	52.9
C	22	47.6	40.5
D	35	38.0	32.4
D	47	38.9	34.4
H	97	69.0	43.0
I	48	8.0	12.0
J	7	5.0	4.0
M	87	69.0	24.4
M	100	66.0	50.2
Ave.		35.2	27.7

TABLE V. Strengths of Single Yarns Made of Karnak and Pima S-1 Cottons

Mill	Yarn Number			Twist Multiplier	Skein Break		Count × Strength Product		
	Nominal	Actual			Karnak (lb)	Pima S-1 (lb)	Karnak	Pima S-1	% Pima S-1 Is of Karnak
		Karnak	Pima S-1						
A	90	85.5	86.3	3.75	31.5	33.9	2690	2920	108.5
A	100	95.1	97.8	4.06	26.8	28.3	2540	2760	108.7
B	26	24.1	23.7	—	144.5	168.4	3480	4000	114.9
B	16	15.3	15.2	—	240.4	285.5	3690	4350	117.9
C	8	8.2	8.0	3.55	230.5	265.4	1878	2122	113.0
C	22	22.2	19.6	3.25	138.4	195.0	3062	3824	124.9
D	35	36.4	35.0	3.33	81.2	99.0	2952	3467	117.4
D	47	47.5	49.1	3.25	60.6	67.0	2874	3280	114.1
E	80	80.1	79.3	3.40	33.8	38.7	2740	3067	111.9
E	90	90.5	88.2	3.15	27.5	31.6	2490	2740	110.0
F	90	89.3	88.5	3.40	28.2	31.2	2517	2761	109.7
F	60	59.9	59.5	3.47	51.1	55.6	3060	3309	108.1
F	78	76.9	76.9	2.81	36.6	40.3	2815	3099	110.1
F	118	117.6	117.6	3.85	18.7	18.3	2199	2152	97.9
G	22	21.8	18.5	3.00	162.0	234.0	3528	3900	110.5
G	30	29.2	27.9	3.25	120.0	135.0	3492	3763	107.8
G	36	35.4	33.1	3.25	93.0	110.0	3291	3637	110.5
G	60	62.1	54.0	3.50	39.0	59.0	2420	3187	131.7
H	97	96.1	96.9	3.58	25.1	27.1	2412	2625	108.8
I	48	49.7	48.9	3.11	60.0	69.0	2980	3377	113.3
J	7	7.2	7.2	3.20	511.0	636.0	3671	4593	125.1
K	70	70.3	70.3	3.69	39.0	45.0	2740	3098	113.1
K	36	35.3	35.2	3.55	95.0	106.0	3353	3728	111.2
K	16	16.5	16.2	3.61	213.0	236.0	3508	3818	108.8
L	40	—	—	3.50	—	—	3094	3600	116.4
L	60	—	—	3.50	—	—	2768	3187	115.1
L	80	—	—	3.50	—	—	2487	3002	120.7
M	100	92.7	96.9	3.25	27.0	29.0	2504	2811	112.3
M	87	86.5	86.1	3.50	27.0	36.0	2336	3099	132.7
N	—	—	—	—	—	—	—	—	—
Ave.									114.0

view of the fact only one yarn made of Pima S-1 was weaker than its paired Karnak in 29 pairs spun. The fact that 13 separate plants making a wide range of yarns with various twists and by several different mill organizations uniformly report Pima S-1 makes stronger yarns leaves little doubt yarns made of Pima S-1 are superior in strength to all others in this test. With reasonable care, and possibly slight adjustments in processing conditions, it could confidently be anticipated that the exclusive use of Pima S-1 in any mill would increase yarn strength by 10%.

Twenty-two yarns were graded by 9 of the mills. In no case did Pima S-1 yarns grade lower than Karnak yarns. The lowest grade made of Pima S-1 was B−, while its control graded C+, which was the lowest grade for Karnak yarns in this test. The paired grades reported were:

Karnak	A−	A−	A−	A−	A−	A−	A	A	A	A				
Pima S-1	A−	A−	A−	A−	A−	A−	A	A	A	A				
Karnak	B	B	B	B	B	B+	B	B	B	B	B	C+		
Pima S-1	B+	B+	B+	B	B+	B+	A	A	A	A	B	B−		

Currently, extra-long staples are used in greatest volume in thread and plied yarns. Ten of the cooperating mills made plied constructions of Pima S-1 tested against similar products made of Karnak (Table VI). In all, 20 plied constructions ranging from heavy 8/6 to light 100/2 were tested. In only two cases was it found that Karnak made stronger plied constructions than Pima S-1.

The range of the ratios of Pima S-1 plied-yarn strength to that of Karnak is 87.4% to 135.9%. These percentages were computed on the basis of the uncorrected (for number) strength of the plied yarns. This is a much wider range than the ratios for singles yarns, which ranged from 107.8 to 132.7%. Within

TABLE VI. Strengths of Plied Yarns Made of Karnak and Pima S-1

Mill	Nominal Construction	Strength of Plied Yarns: Break* Karnak	Break* Pima S-1	% Pima S-1 Is of Karnak	% Pima S-1 Singles Is of Karnak Singles†
B	16/4-Z	9.33	10.61	113.7	117.9
B	26/4-Z	6.15	6.89	112.0	114.9
C	8/6-Z	29.37	31.03	105.7	113.0
C	22/4-Z	108.44	132.48	122.2	124.9
D	35/3-Z	46.00	51.31	111.5	117.4
D	47/4-Z	48.76	52.98	108.7	114.1
F	60/3-Z	1.675	1.697	101.3	108.1
F	78/2-Z	0.700	0.752	107.4	110.1
G	22/4-Z	6.4	8.7	135.9	110.5
G	30/3-Z	3.7	4.3	116.2	107.8
G	36/2-Z	1.93	2.21	114.5	110.5
G	60/2-Z	1.02	1.37	134.3	131.7
H	100/2/6-SZ	2.19	2.49	113.7	108.8
I	48/3-Z	2.30	2.01	87.4	113.3
K	16/4-Z	9.40	10.60	112.8	108.8
K	36/3-Z	3.06	3.29	107.5	111.2
K	70/2-Z	0.84	0.97	115.5	113.1
M	87/2-Z	11.18	11.15	99.7	132.7
M	100/2-S	7.83	9.42	120.3	112.3
N	21/4-Z	6.18	7.51	121.5	—
Ave.‡				112.6	114.8

* Reported variously in ounces, pounds, skeins, and single ends.
† Taken from Table V.
‡ Omits Mill N.

the group the results are erratic, but in general Pima S-1 performs almost as well in plied yarns (112.6%) as in singles (114.8%). With the two averages being so close, the expectation is that about half the plied-singles comparisons would show Pima S-1 performed fully as well in plied constructions as in the singles from which the plies were made. This is true in this set of data; for of 19 pairs of results, 8 showed that Pima S-1 performed better in plied yarns than it did in the singles used for making the corresponding plied yarns.

Almost the entire program of the cooperating mills was centered on singles and plied yarns. Nevertheless, several other observations, most of them with supporting data, show that Pima S-1, in terms other than strength of gray yarns, has as high utility as does Karnak.

(*a*) Two mills reported plied yarns finished and dyed in several ways showed that all Pima S-1 treated yarns were stronger than Karnak yarns receiving similar treatments.

(*b*) Pima S-1 yarns do not, upon mercerization, increase as much percentage-wise in strength as do Karnak yarns. Nevertheless, the Pima S-1 mercerized yarns are still stronger than the Karnak mercerized yarns.

(*c*) One mill reported Pima S-1 equaled Karnak in dyeing, finishing, and sewing tests. Another mill confirmed the findings as to dyeing and finishing, but neither offered supporting quantitative data.

(*d*) One mill wove 3.83-oz 144 × 76 cloth which tested thus:

	Karnak	Pima S-1
Warp-Wise Strength	119	135
Filling-Wise Strength	69	77

(*e*) One mill made observations, unaccompanied by quantitative data, on efficiencies of operations after spinning. It found there were more reties at the spooler for Pima S-1 than for Karnak, but that, in warping, quilling, twisting, and weaving, Pima S-1 was equal to or better than Karnak.

Whether or not subsequent crops of Pima S-1 will equal these results cannot, of course, be forecast. Cotton breeders are making further selections within this strain with the intention of maintaining or improving its yield and quality. They are also working on a wide range of other breeding materials to find even better basic extra-long staple strains; this is being done not only in the United States, but also in Egypt and Peru. As of now, it appears users of extra-long staples can be assured of an adequate world supply of high qualities in these staples for many years to come.

Summary

1. Fourteen plants making a wide range of yarn numbers cooperated in commercial spinning tests of a new extra-long staple cotton, Pima S-1.

2. Egyptian-grown Karnak was generally used as the control cotton. The fiber properties of Pima S-1 show it to be slightly shorter and slightly weaker than Karnak, but it is coarser and has superior fiber-length uniformity as compared to Karnak.

3. In the manufacturing factors of waste losses, noils removed, and ends down, Pima S-1 is equal to or slightly better than Karnak.

4. Although Pima S-1 appears to make fewer neps than previous commercial strains of American-

Egyptians, it usually makes a few more neps than Karnak.

5. All mills were uniformly successful in making stronger singles yarns from Pima S-1 than from Karnak. The average yarn strength increase was 14%. Yarn grades were equal to or better than those made from Karnak.

6. On the average, plied yarns made of Pima S-1 were 13% stronger than were those made of Karnak.

Acknowledgment

A project of the magnitude of the one reported in this article requires the cooperation of many persons and organizations. Each cooperator has an essential and unique contribution to make, and without that contribution the work could well result in failure. The compiler of this article, of course, assumes all responsibility for the interpretations of the data supplied by the participants in these tests. Organizations participating in the commercial test of the 1953 crop of Pima S-1 were:

American and Efird Mills, Inc.
  Adrian Plant
  Rush Plant
American Thread Company, Inc.
  Willimantic, Connecticut, Plant
  Newman, Georgia, Plant
  Troutman, North Carolina, Plant
Arizona Agricultural Experiment Station
  Agronomy Department
Arizona Cotton Planting Seed Distributors
Carlton Yarn Mills, Inc.
China Grove Cotton Mills Company
Coats & Clark, Inc.
  Pelham, Georgia, Plant
  Pawtucket, Rhode Island, Plant
Groves Thread Company
National Cotton Council
Shaw Cotton Company
  Phoenix, Arizona, Office
J. P. Stevens & Company
  Aragon Baldwin Mill Division
Textiles, Inc.
Textile Thread Company
United States Department of Agriculture
  Agricultural Research Service
    Cotton and Other Fiber Crops Section, Sacaton Field Station
    Southern Utilization Research Branch, Southern Regional Research Laboratory

Evaluation of Yarn Properties and Processing Performance of Pima S-1 Cotton

John J. Brown, Nathaniel A. Howell, Louis A. Fiori, and Jack E. Sands

Southern Regional Research Laboratory, New Orleans, Louisiana [1]

Abstract

Results are reported of a pilot plant evaluation of Pima S-1 cotton using an Egyptian variety, Karnak, and an American-Egyptian variety, Pima 32, as controls. The three cottons were processed alike on conventional equipment into a range of relatively fine single- and 2-ply yarns.

Certain organizational details were varied within limits to aid in the evalution of the processing performance of the three cottons, and to determine the contributions each cotton made toward product quality.

Each cotton was divided into three lots which were carded at 4, 6, and 8 lb/hr, respectively. Each lot was then combed, with 15 and 18% noils being removed. Twist-strength relationships were determined by spinning the yarns with a range of twist multipliers from 3.00 to 4.00 in increments of 0.25; draft-strength relationships were determined by spinning the yarns with a range of drafts from 14 to 53, using the twist multiplier found previously to produce maximum strength. The effect of the method of creeling was determined by spinning the same yarn number from a series of hank rovings both single and double creeled. Evaluation was made of gain in strength of 2-ply over single yarns using the same twist multiplier in both single and ply yarns. Also, an assessment was made of the response of these three cottons to three conditions of mercerizing and to subsequent dyeing.

An analysis was made of opening-, picking-, and carding-waste percentages and of the uniformity of slivers and yarns. Yarn quality was determined by measuring skein and single-strand strengths, elongation, and appearance, and from the coefficient of variation of the strength values and Uster uniformity tester measurements.

It was found that, within the limits of this study, the general processing performance of the Pima S-1 was equal to that of the Karnak and Pima 32 cottons. Regardless of the organizational variables used in the evaluation, the Pima S-1 cotton produced yarns of better appearance and uniformity than did the other two cottons. Also, yarns made from Pima S-1 were stronger than those made from Karnak, and were generally equal in strength to yarns made from Pima 32. Double creel produced stronger and more uniform yarns than did single-creel spinning for all the cotton varieties tested. The performance of Pima S-1 in 2-ply constructions was equal to that of the two control cottons. The general response of Pima S-1 to mercerizing and to subsequent dyeing was slightly better than that of the other cottons.

Introduction

A comprehensive program to evaluate the commercial potentialties of Pima S-1 cotton, a new interspecies, has recently been completed. The need for this evaluation, details of the program, and results obtained by the cooperating mills and laboratories have been reported by Johnson of the National Cotton Council of America [3].

This report presents the results of a pilot plant evaluation of Pima S-1 cotton using the Egyptian variety Karnak and the American-Egyptian variety Pima 32 as controls. An assessment was made of the influence of carding rates, comber settings, spinning drafts and twists, and method of creeling roving at the spinning frame on uniformity, appearance, and

[1] One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

Pima S-1 Karnak Pima 32

Fig. 1. Cross-sectional photomicrographs.

TABLE I. Summary of Fiber Properties

Fiber Property	Variety		
	Pima S-1	Karnak	Pima 32
Grade	Grade 3	Fully Good–¼ to Good/Fully Good	Grade 2
Length			
Classer (in.)	1 7/16	1 7/16	1½
Suter-Webb			
U.Q. (in.)	1.42	1.35	1.54
Mean (in.)	1.22	1.07	1.26
C.V. (%)	24	34	31
Fibrograph			
U.H.M. (in.)	1.37	1.25	1.45
Mean (in.)	1.16	0.96	1.18
U.R.	85	77	81
Fineness			
Suter-Webb (μg/in.)	3.2	2.8	2.8
Micronaire	3.9	3.2	3.4
Arealometer			
Specific area (mm^2/mm^3)	486	550	522
Maturity			
Sodium hydroxide method (%)	94	86	89
Strength and elongation			
Pressley index (lb/mg)	8.92	9.18	9.56
Stelometer			
Tenacity (g/grex)			
0 mm	3.70	3.75	4.10
2.5 mm	2.75	2.50	2.92
4.0 mm	2.56	2.32	2.58
Elongation (%)			
0 mm	—	—	—
2.5 mm	8.0	6.0	5.2
4.0 mm	8.2	6.3	6.0

strength of single yarns. The general processing characteristic of the cottons and the gain in strength of 2-ply yarns over single yarns, using the same single- and ply-yarn twist multipliers, are also discussed. The study should prove of service in determining the value of Pima S-1 cotton for various end uses.

Materials and Methods

Samples

The control cottons used in this evaluation of Pima S-1 cotton were an American-grown long-staple variety, Pima 32, and an Egyptian variety, known as Karnak. The bale of Pima S-1 cotton was one of a random selection made from the 1953 commercial crop. These bales were offered to the cooperating groups, including this Laboratory, for participation in the evaluation program. The control bales were purchased on the open market.

Since fiber properties of a cotton determine the processing characteristics and the physical properties of its yarns, the fiber properties of Pima S-1 as compared to Karnak and Pima 32 should be examined closely. These properties are shown in Table I.

A comparison of these properties would rate the Pima S-1 as follows:

Length. Classer: The same as Karnak and shorter than Pima 32. Suter-Webb, upper quartile: Longer than Karnak and shorter than Pima 32.

Strength. Pressley index: Weaker than both Karnak and Pima 32. Stelometer: Weaker than

Karnak and Pima 32 at so-called "0" gage length; stronger than Karnak but weaker than Pima 32 at 2.5-mm gage length; and stronger than Karnak and about as strong as Pima 32 at 4.0-mm gage length.

Fineness. Suter-Webb, Micronaire (curvilinear scale), and Arealometer: Coarser than both Karnak and Pima 32.

Length uniformity. Suter-Webb and Fibrograph: A much more uniform fiber population than either Karnak or Pima 32. The Pima S-1 has an unusually low coefficient of length variability (24%) when compared with the Karnak (34%) and Pima 32 (31%). The unusual fiber length uniformity of this new variety should contribute materially towards making stronger and more uniform yarns.

Fiber elongation. Stelometer: More than either the Karnak or Pima 32.

Grade. Higher than the Karnak and lower than the Pima 32. (Exact grade comparisons between American-Egyptian and Egyptian cottons are difficult to make. However, a general comparison can be made.)

Figure 1 shows photomicrographs of these three cottons. This sample of Pima S-1 appears to contain more full-bodied fibers than either of the other two cotton samples pictured. Such a difference is not necessarily a varietal characteristic since it is often associated with environmental influences. However, the uniformity of fiber size and shape shown here in Pima S-1 is generally considered advantageous from a processing standpoint.

All evaluations and comparisons made in this study should be considered with these fiber property comparisons in mind, particularly grade comparisons; and only one bale of each variety was used.

Processing and Testing Procedures

All three cottons were processed alike on conventional equipment into the desired hank rovings and range of relatively fine yarns. The processing organization used is shown in Figure 2.

Evaluations at the card and the comber were made at varying carding rates (4, 6, and 8 lb/hr) and noil percentages removed (15 and 18%).

To establish a reliable twist-strength relationship and obtain points of maximum strength, yarns were spun with a range of twist multipliers from 3.00 to 4.00 in increments of 0.25.

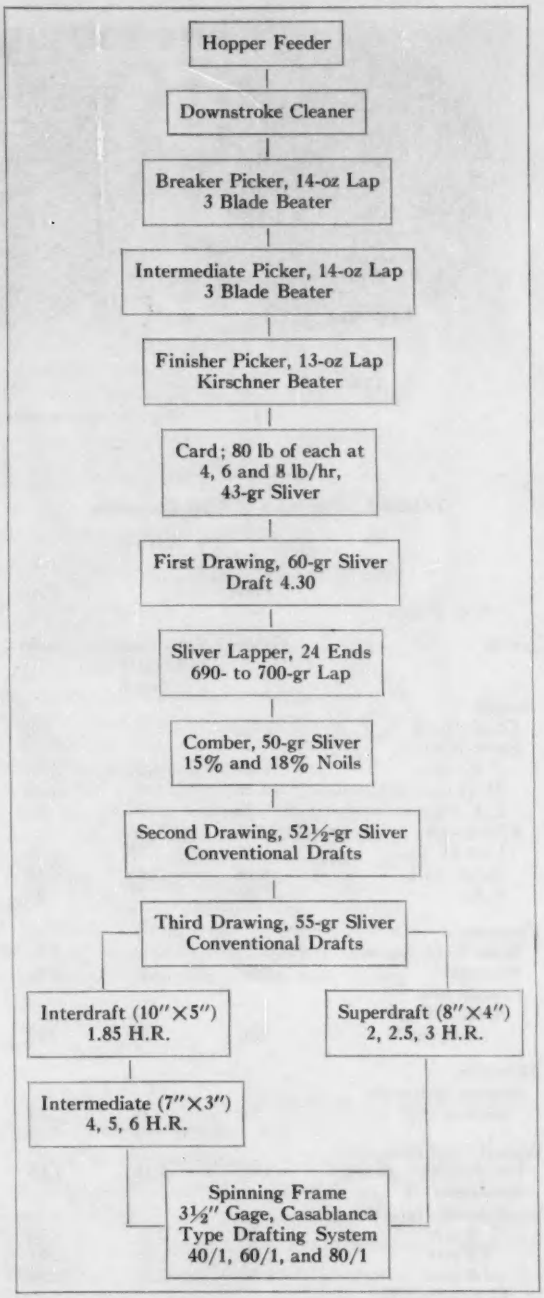


Fig. 2. Processing organization; 300 lb each of Karnak, Pima 32, and Pima S-1 were fed. gr = grain. H.R. = hank roving.

TABLE II. Effects of Carding Rates on Yarn Strength *

Carding Rate (lb/hr)	Pima S-1 Count-Strength Product†		Karnak Count-Strength Product†		Pima 32 Count-Strength Product†	
	Skein	Single Strand	Skein	Single Strand	Skein	Single Strand
40/1						
4	3583	458	3122	384	3567	436
6	3610	461	3126	386	3544	444
8	3608	444	3033	375	3558	434
60/1						
4	3251	426	2812	358	3318	402
6	3182	420	2809	357	3135	400
8	3127	420	2684	352	3112	399
80/1						
4	3123	385	2500	329	2980	376
6	2963	401	2517	336	2915	387
8	2920	343	2443	324	2885	381

* 15% comber noils removed from stock with yarns being spun from double-creeled 6-hank roving, using a 3.50 T.M.
† Yarn number multiplied by skein strength in pounds, and single-strand strength in ounces, respectively.

To study the draft-strength relationships the yarns were spun with a twist multiplier of 3.50 (found in twist-strength study to give maximum strength) from hank rovings selected to give a range of drafts from 14 to 53. These included drafts of 14, 18, 22, 30, 35, 42, 48, and 53.

The evaluation of single- versus double-creel spinning was incorporated in the twist-strength study by first spinning 40/1, 60/1, and 80/1 yarns from 3-hank roving, single creeled, and then spinning the same yarn numbers from 6-hank roving, double creeled. This gave a comparison of single- versus double-creel spinning over a range of yarn numbers and twist multipliers with the draft being constant for a given yarn number.

Neps were counted [2] at 10 min and 70 min after each stripping cycle, of which there were four for each carding rate. Two templates were taken from each side and the middle of the card web. Averaged results of the four stripping cycles are reported as number of neps per hundred square inches of card web. Sliver uniformity was measured on a converted Saco-Lowell sliver tester [2] [4]; yarn uniformity on a Uster uniformity tester [2] equipped with a quadratic integrator.[2] Skein-strength determinations were made on a pendulum-type tester of 0 to 150 lb capacity; single-strand strength and elongation measurements were made on an Uster single strand tester;[2] and yarn appearance was graded in accordance with ASTM procedures [1]. Fiber properties, except those obtained by the Stelometer [5], were determined by ASTM methods [1].

Discussion of Results

Certain organizational details were varied within limits to aid in the evaluation of the processing performance of the three cottons, and to determine the

[2] Mention of trade names does not imply their endorsement by the Department of Agriculture over similar products not mentioned.

TABLE III. Effects of Carding Rates on Yarn Uniformity *

Carding Rate (lb/hr)	Pima S-1			Karnak			Pima 32		
	Skein† (C.V.) (%)	Single Strand† (C.V.) (%)	Uster‡ (C.V.) (%)	Skein† (C.V.) (%)	Single Strand† (C.V.) (%)	Uster‡ (C.V.) (%)	Skein† (C.V.) (%)	Single Strand† (C.V.) (%)	Uster‡ (C.V.) (%)
40/1									
4	4.27	11.23	15.2	6.24	11.05	18.6	6.63	10.38	16.7
6	4.65	9.52	14.8	5.74	9.88	18.6	5.76	9.11	16.8
8	3.85	9.66	15.2	4.43	11.09	18.1	5.10	10.25	16.7
60/1									
4	4.61	11.26	—	5.91	12.22	—	5.16	9.19	—
6	6.64	10.57	18.1	5.16	13.02	21.8	4.81	10.17	19.0
8	7.07	11.91	18.4	4.78	11.33	21.6	5.38	10.32	20.3
80/1									
4	4.70	12.65	21.0	7.40	11.72	26.3	5.43	11.80	20.9
6	8.29	10.35	20.0	6.00	12.23	23.4	7.33	11.42	21.1
8	7.67	16.02	19.8	4.62	12.91	23.5	8.24	12.36	21.2

* 15% comber noils removed from stock with yarns being spun from double-creeled 6-hank roving, using a 3.50 T.M.
† Calculated from breaking-strength values by statistical methods.
‡ Measured by Uster evenness tester.

TABLE IV. Effects of Carding Rates on Yarn Appearance *

Carding Rate (lb/hr)	Pima S-1	Karnak	Pima 32
40/1			
4	A−	B−	B
6	B+	C	B−
8	B−	C	C+
60/1			
4	A	C+	B+
6	B+	C	B
8	B	C+	B
80/1			
4	B	C+	B−
6	B−	C−	C−
8	C+	D	D+

* 15% comber noils removed from stock with yarn being spun from double-creeled 6-hank roving, using a 3.50 T.M.

contributions each cotton made towards product quality. The organizational variables evaluated were: (1) carding rates; (2) comber-noil percentages removed; (3) spinning drafts; (4) twist multipliers; (5) method of creeling roving at the spinning frame (double versus single creel); (6) gain of ply over single-yarn strength; (7) mercerizing and dyeing behavior.

In addition, an analysis was made of opening-, picking-, and carding-waste percentages, effects of carding rates on nep formation and sliver uniformity, and the general processing behavior of these cottons.

Effects of Carding Rates on Yarn Properties and Nep Formation

This evaluation was made on yarns spun using a 3.5 T.M. from double-creeled 6-hank roving with 15% noils removed at the comber. Table II shows the effects of carding rates on yarn strength. Generally, the carding rates used did not materially affect the yarn strength, regardless of method of test or cotton variety. A possible exception was noted in the skein strength where slight losses in strength occurred with increases in carding rates. Although these strength losses are somewhat consistent, the differences in count-strength products are small and probably would not be considered significant.

Table III shows the effects of carding rates on yarn uniformity. Coefficients of variation calculated from breaking-strength values showed no apparent trends due to changes in carding rates regardless of cotton varieties. The same was true with uniformity values as measured by the Uster uniformity tester, except that in general the Pima S-1 yarns were more uniform than yarns made from either the Karnak or Pima 32 cottons.

TABLE V. Effects of Carding Rates on Nep Formation

Variety	Carding Rate (lb/hr) 4	6	8
	(neps/100 sq in.)		
Pima S-1			
10 min after stripping	18.3	21.7	56.5
70 min after stripping	19.6	27.3	67.1
Karnak			
10 min after stripping	28.5	42.7	56.3
70 min after stripping	29.8	64.6	94.0
Pima 32			
10 min after stripping	23.3	37.7	35.6
70 min after stripping	20.6	47.2	38.5

Table IV shows the effects of carding rates on yarn appearance. The data show that the yarns made from Pima S-1 were consistently better in appearance than similar yarns made from Pima 32 or Karnak when processed under the same conditions.

In addition, it is also significant that the yarn grades of the Pima S-1 carded at a rate of 8 lb/hr were as high as or higher than those of the other two cottons carded at a rate of 6 lb/hr for all the yarn numbers evaluated.

As was expected, the yarns made from stock carded at 4 lb/hr were better in appearance than yarns made from stock carded at 6 and 8 lb/hr.

Effects of Carding Rates on Nep Formation

Table V shows a comparison of the neps formed at three carding rates with the nep count being taken 10 min and 70 min after stripping.

TABLE VI. Effects of Per Cent Comber Noils Removed on Yarn Strength *

Comber Noils Removed (%)	Pima S-1 Count-Strength Product† Skein	Pima S-1 Single Strand	Karnak Count-Strength Product† Skein	Karnak Single Strand	Pima 32 Count-Strength Product† Skein	Pima 32 Single Strand
40/1						
15	3583	458	3122	384	3567	436
18	3593	432	3080	340	3571	414
60/1						
15	3251	426	2812	358	3318	402
18	3225	385	2773	323	3245	418
80/1						
15	3123	385	2500	329	2980	376
18	3008	384	2572	311	2903	385

* Stock carded at 4 lb/hr with yarns being spun from double-creeled 6-hank roving, using a 3.50 T.M.

† Yarn number multiplied by skein strength in pounds, and single-strand strength in ounces, respectively.

TABLE VII. Effects of Per Cent Comber Noils Removed on Yarn Uniformity *

Comber Noils Removed (%)	Pima S-1 Skein† (C.V.) (%)	Pima S-1 Single Strand† (C.V.) (%)	Pima S-1 Uster‡ (C.V.) (%)	Karnak Skein† (C.V.) (%)	Karnak Single Strand† (C.V.) (%)	Karnak Uster‡ (C.V.) (%)	Pima 32 Skein† (C.V.) (%)	Pima 32 Single Strand† (C.V.) (%)	Pima 32 Uster‡ (C.V.) (%)
40/1									
15	4.27	11.23	15.2	6.24	11.05	18.6	6.63	10.38	16.7
18	4.98	4.90	14.2	4.04	9.76	17.0	4.89	7.28	15.0
60/1									
15	4.61	11.26	—	5.91	12.22	—	5.16	9.19	—
18	6.65	14.92	17.5	5.06	6.06	20.2	7.48	9.92	17.9
80/1									
15	4.70	12.65	21.0	7.40	11.72	26.3	5.43	11.80	20.9
18	6.40	14.60	18.0	7.53	14.88	21.2	7.07	16.01	19.4

* Stock carded at 4 lb/hr with yarns spun from double-creeled 6-hank roving, using a 3.50 T.M.
† Calculated from breaking-strength values by statistical methods.
‡ Measured by the Uster evenness tester.

The data show that Pima S-1 produced a card web having substantially less neps than the Karnak and Pima 32 cottons when carded at 4 or 6 lb/hr. The percentage increase in neps formed when the carding rate increased from 4 to 6 lb/hr was much less for Pima S-1 than for either of the other two cottons. It would appear that the Pima S-1 can probably be carded at a higher rate (up to 6 lb/hr.) than the other cottons while producing a web of equal quality.

Effects of Per Cent Comber Noils Removed on Yarn Properties

The yarns evaluated were spun from double-creeled 6-hank roving, using a 3.5 T.M. with the stock being carded at 4 lb/hr. Table VI shows the effects of different percentages of noils removed on yarn strength. Yarn strength was not significantly affected by the percentages of noils removed for the three cottons although there was a slight tendency for both skein- and single-strand strength to drop (6 out of 9 and 7 out of 9 cases, respectively) with increases in percentage comber noils removed. The differences in noil percentages removed evidently was too small to cause any practical changes in yarn strength.

Table VII shows the effects of per cent comber noils removed on yarn uniformity. The Uster uniformity data indicate that yarns with 18% noils removed were consistently more uniform than yarns with 15% noils removed for all three cottons, with the yarns made from Pima S-1 cotton being consistently more uniform than the yarns made from Karnak and Pima 32 cottons.

Coefficients of variation calculated from skein- and single-strand strength values exhibited no definite trend.

Table VIII shows the effects of comber noils removed on yarn appearance.

For a carding rate of 4 lb/hr the difference in yarn grades for 15 and 18% noils removed was insignificant for all the cottons. The difference in noil percentage removed may have been too small to allow for detection by such a subjective method of yarn appearance evaluation as was used. Even when a comparison is made on this basis, however, the Pima S-1 maintains its position of quality with respect to the control cottons.

TABLE VIII. Effects of Comber Noils Removed on Yarn Appearance *

Comber Noils Removed (%)	Pima S-1	Karnak	Pima 32
40/1			
15	A−	B−	B
18	A−	B−	B
60/1			
15	A	C+	B+
18	A	B	A−
80/1			
15	B	C+	B−
18	B+	C	B−

* Stock carded at 4 lb/hr with yarn spun from double-creeled 6-hank roving, using a 3.50 T.M.

Effects of Draft on Yarn Properties

In the draft study the yarns evaluated were spun from six different roving numbers, double creeled, using a 3.5 T.M. The stock was carded at 4 lb/hr with 15% comber noils being removed at the comber.

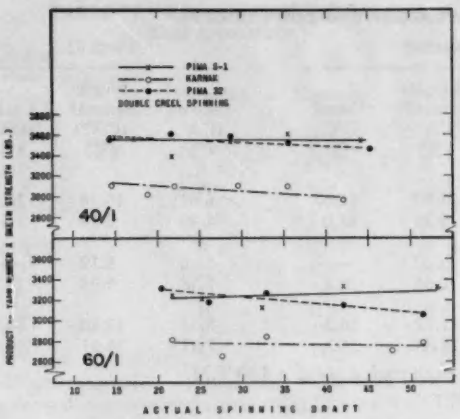


Fig. 3. Effects of draft on skein count-strength products of 40/1 and 60/1 combed cotton yarns.

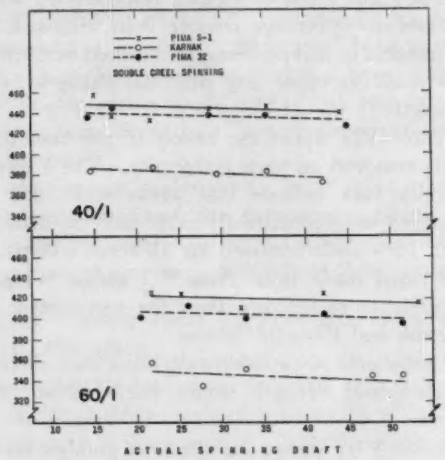


Fig. 4. Effects of draft on single-strand count-strength products of 40/1 and 60/1 combed cotton yarns.

Figure 3 shows actual spinning draft plotted against skein count-strength products for 40/1 and 60/1 yarns spun from the three cotton varieties. Plots for the 80/1 yarns were excluded since the data were similar to those of the 40/1 and 60/1 yarns.

For practical purposes the effects of spinning draft on strength are negligible, although there was a tendency for the yarn strength to decrease slightly with an increase in draft; however, considering the range of drafts used, the change in yarn strength with a practical change in drafts would probably be insignificant. This indicates that the Pima S-1 could be spun at relatively high drafts with no appreciable sacrifice in strength and at the same degree of efficiency as the other two varieties. Incidentally, the use of high drafts might introduce other difficulties such as ends down and eyebrowing, which cannot be reliably evaluated on a pilot plant basis.

Figure 4 shows the effects of draft on single-strand count-strength products of 40/1 and 60/1 yarns. These curves are similar to those in Figure 3, and generally the same conclusions may be drawn concerning the effects of draft on yarn strength.

It is interesting to note that for both methods of test and for any draft, yarns made from the Pima S-1 cotton are approximately as strong as those made from the Pima 32 and much stronger than those made from the Karnak.

Table IX shows the effects of spinning draft on yarn uniformity. The data indicate that spinning draft did not materially affect yarn uniformity regardless of cotton variety or yarn number. However, the Pima S-1 yarns were more uniform than yarns made from Karnak or Pima 32 for a given draft and yarn number.

TABLE IX. Effects of Spinning Draft and Creeling on Yarn Uniformity *

	Coefficient of Variation†								
	Hank Roving								
	2			4			6		
	Pima S-1 (%)	Karnak (%)	Pima 32 (%)	Pima S-1 (%)	Karnak (%)	Pima 32 (%)	Pima S-1 (%)	Karnak (%)	Pima 32 (%)
40/1									
Single creel	16.9	20.4	18.0	16.5	20.0	18.0	16.3	18.6	14.9
Double creel	15.5	19.5	17.8	16.6	18.3	16.3	15.2	18.6	16.7
80/1									
Single creel	—	—	—	22.1	24.4	22.2	20.4	24.1	22.1
Double creel	—	—	—	18.4	22.8	20.7	21.0	26.3	20.9

* Stock carded at 4 lb/hr with 15% noils removed and yarns spun with a 3.50 T.M.
† Measured by the Uster evenness tester.

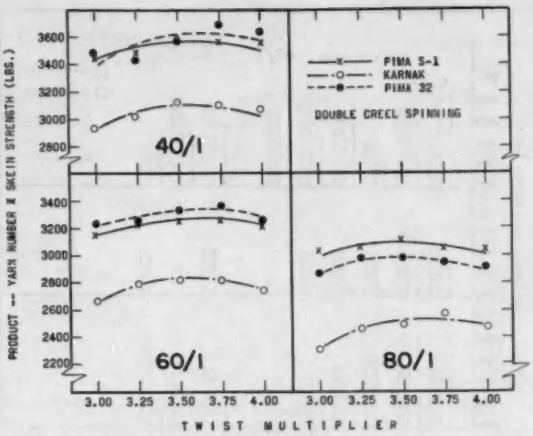


Fig. 5. Effects of twist on skein count-strength products of 40/1, 60/1, and 80/1 combed cotton yarns.

Effects of Twist on Yarn Properties

A series of yarn numbers were spun from single-creeled 3-hank roving and double-creeled 6-hank roving, using a selected range of twist multipliers. The twist-skein strength relationships are shown in Figure 5 for the double-creeled roving. Generally, the three cottons reacted similarly to a given change in twist multiplier over the range of yarn numbers evaluated. Regardless of variety, approximately the same amount of twist is required to reach maximum skein strength, as would be expected since the cottons had approximately the same length and fineness. It is significant that, even though the Pima S-1 is shorter (upper-quartile and upper-half mean length), coarser, and weaker (Pressley) than the Pima 32, it produced, in most cases, yarns which were as strong or stronger than comparable yarns produced from the Pima 32. Likewise, the Pima S-1, though somewhat longer in length (upper-quartile and upper-half mean length) but coarser and weaker (Pressley) than Karnak, produced yarns which were 15 to 25% stronger than those made from Karnak. When fiber properties were used as a basis of comparison, the Pima S-1 was not expected to produce such strong yarns. A reasonable explanation for the behavior of this variety may be the influence on yarn strength of greater fiber elongation and unusually uniform fiber-length distribution. Based on the experimental conditions of this test, it would appear that Pima S-1 may produce stronger yarns than Karnak, at lower twists.

Figure 6 shows the effects of twist on single-strand count-strength products of 40/1, 60/1, and 80/1 yarns. These curves are quite similar to those of skein values shown in Figure 5 with the exception that yarns made from Pima S-1 are definitely stronger (15–20%) than yarns made from Karnak and slightly stronger than yarns made from Pima 32.

The effects of twist on yarn elongation at break are given in Figure 7, where it is shown that the

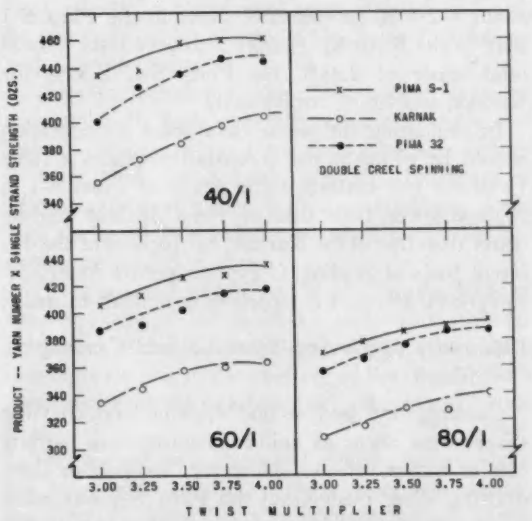


Fig. 6. Effects of twist on single-strand count-strength products of 40/1, 60/1, and 80/1 combed cotton yarns.

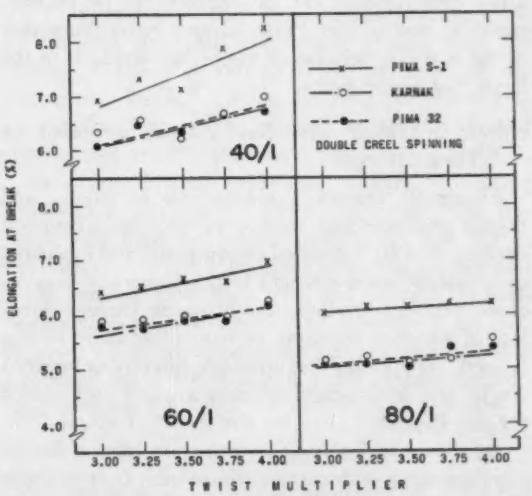


Fig. 7. Effects of twist on elongation at break of 40/1, 60/1, and 80/1 combed cotton yarns.

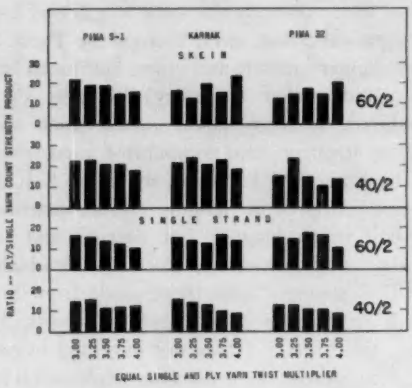


Fig. 8. Skein and single-strand count-strength product ratios of 40/2 and 60/2 to 40/1 and 60/1 combed cotton yarns, double creeled.

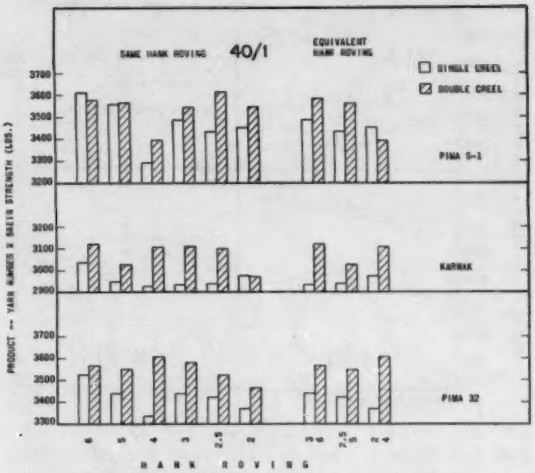


Fig. 9. Effects of single- vs. double-creel spinning on skein count-strength products of 40/1 combed cotton yarns.

Pima S-1 yarns, regardless of twist or yarn number, had about 17% more elongation than yarns made from either the Karnak or Pima 32 cottons. The Pima S-1 cotton produces yarns of higher than average elongation for a given yarn number.

Figure 8 shows the per cent gain in strength, based on count-strength products, of 2-ply over single yarns, spun double creeled and 2-ply twisted with the same twist multiplier. With any twist combination, either method of test or yarn number shown, the Pima S-1 gained approximately the same as the two control cottons, strengthwise, in being 2-ply twisted. The behavior of Pima S-1 in 2-ply constructions can be expected to be at least equal to that of the Pima 32 and better than that of the Karnak, because of the higher strength of the Pima S-1 single yarns.

Effects of Single- and Double-Creel Spinning on Yarn Strength

Figure 9 presents a comparison of single- and double-creel spinning, using a variable and a constant draft to spin 40/1 combed cotton yarns and evaluated on a basis of skein-strength tests. Generally, double-creel spinning produces the stronger yarns regardless of whether the same or equivalent hank roving is used. It appears that strength differences between single- and double-creel spinning are less pronounced for the Pima S-1 than for the control cottons.

As shown in Table IX, yarns spun from a double creel are more uniform than those spun from a single creel regardless of draft, yarn number, or cotton variety.

Effects of Processing on Total Waste

Table X gives a comparison of the percentage of waste removed at the opening, picking, carding, and combing operations.

Total waste percentages for Pima S-1 and Pima 32 are comparable and are about 1.5% less than those for Karnak. It can therefore be concluded that the Pima S-1 can be processed at least as efficiently as Karnak and Pima 32 in the opening, picking, and carding operations with the possibility of retaining about 1–2% more spinnable fibers in the Pima S-1 than in the Karnak. Shirley Analyzer tests showed total waste of 2.85% for Pima S-1, 2.38% for Karnak, and 1.80% for Pima 32.

In evaluating the waste data some consideration should be given to the comparative grades (Table I) of the test cottons. The grade of Pima S-1 is slightly lower than that of Pima 32 and slightly better than that of the Karnak, but because of the different basis of grading (Egyptian versus American-Egyptian) an exact comparison is difficult to make.

Uniformity of Carding, Drawing, and Combing Slivers

Carding, first and second drawing and combing slivers were about as uniform regardless of carding rate or cotton variety. However, the final or third drawing sliver made from the Pima S-1 was more uniform than the sliver made from either of the other two cottons. Since the fine yarns produced from the

TABLE X. Summary of Waste Data

Process	Pima S-1 (%)			Karnak (%)			Pima 32 (%)		
Opening*	0.96			1.01			0.43		
Picking*	1.08			1.70			0.80		
	Carding Rate (lb/hr)			Carding Rate (lb/hr)			Carding Rate (lb/hr)		
	4 (%)	6 (%)	8 (%)	4 (%)	6 (%)	8 (%)	4 (%)	6 (%)	8 (%)
Carding*									
Flat strips	6.23	4.84	4.20	6.54	5.34	4.52	6.40	5.03	4.45
Cylinder and doffer strips	0.82	1.13	1.20	0.95	1.14	1.29	0.83	1.05	1.21
Motes and fly	0.96	0.73	0.63	0.94	1.65	1.41	1.10	0.84	0.80
Sweeps	0.13	0.14	0.10	0.13	0.20	0.27	0.13	0.34	0.20
Total	8.14	6.84	6.13	8.56	8.33	7.49	8.46	7.26	6.66
Total Opening, Picking, and Carding†	10.00	8.73	8.04	11.02	10.80	9.98	9.59	8.40	7.81
Total Opening, Picking, Carding, and Combing†	23.50‡	22.42	21.83	24.37	24.18	23.48	23.15	22.14	21.64
	26.20§	25.16	24.59	27.04	26.86	26.18	25.86	24.89	24.40

* Based on net weight fed at process.
† Based on weight fed to bale breaker.
‡ Based on 15% comber noils removed.
§ Based on 18% comber noils removed.

Pime S-1 were more uniform than those produced from the other two varieties, this conclusion appears valid.

Mercerizing and Dyeing Behavior

Samples of 36/2 yarns of the three cottons spun and 2-ply twisted with a 3.00 T.M. were mercerized by a skein process which usually has very nearly the same effects as commercial mercerization and also by processes which allowed (1) extreme shrinkage and (2) 3% stretch.

Visually, the skeins mercerized at the usual or normal length were generally similar in color and luster. However, the Pima S-1 yarn was lighter in color than the Karnak, possibly slightly more lustrous, and gave a slightly clearer and darker shade with the usual direct blue used when comparing the dyeing properties of yarns.

The Pima S-1 shrunk more (by nearly 10% of the shrinkage of the Karnak) and, when suitably restrained at normal length, developed nearly 20% more tension due to the swelling of the fibers. Both effects are evidence of a better response to mercerization.

The Karnak and Pima S-1 cottons gained about the same percentage of strength from mercerizing, but since the Pima S-1 was stronger initially it was stronger after mercerizing, by about 17%.

Results from other tests not described were consistent with those given above.

General Processing Behavior

All three cottons processed equally as well from opening through the final drawing stage with the exception of combing. Some processing difficulties were experienced in combing Pima S-1 and Pima 32. There was a tendency for these cottons to lap around the draw-box rolls and the detaching rolls and to fill the half laps with fibers more quickly than the Karnak. These conditions were improved by reducing the humidity while combing the Pima cottons. The Pimas were combed at 47% R.H. and the Karnak at 58% R.H. at a temperature of 75°F.

In a very limited experiment a very interesting observation was made when the same machine settings were used for both Karnak and Pima S-1 at the comber. It was found that when the comber was set to remove 15% noils from the Karnak approximately 10% noils were removed from the Pima S-1. A more extensive experiment on combing has substantiated these differences in combing-noil percentages between the Pima S-1 and Karnak cottons.

Conclusions

1. The general processing efficiency of Pima S-1 was equal to that of either the Karnak or Pima 32.

2. The Pima S-1 nepped less readily than Karnak or Pima 32.

3. For a given twist, Pima S-1 consistently made a stronger yarn than Karnak and yarns equally as strong as the Pima 32, with the amount of twist required to obtain maximum strength being approximately the same for all three varieties.

4. For a given draft, yarns made from Pima S-1 cotton were consistently stronger than those made from Karnak or Pima 32 cotton when processed under the same conditions.

5. Yarns made from Pima S-1 were consistently more uniform than those made from Karnak or Pima 32.

6. Yarns made from Pima S-1 cotton had about 17% more elongation than the yarns produced from the Karnak and Pima 32 cottons.

7. Yarns spun from double-creeled roving were stronger and more uniform than those spun from single-creeled roving, regardless of cotton variety or processing variables evaluated.

8. Two-ply yarns made from Pima S-1 cotton showed about the same percentage gain in strength as those made from the two control cottons.

9. The general response of Pima S-1 to mercerizing and to subsequent dyeing was slightly better than the other cottons.

Acknowledgment

The authors wish to express their appreciation to members of the Cotton and Other Fiber Crops Section, Field Crops Research Branch, for their assistance in the selection of the Pima S-1 and Pima 32 cottons.

The authors also wish to express their sincere thanks and gratitude to fellow staff members of the Cotton Mechanical Processing Section for processing the cottons into rovings and yarns, and for making the calculations and charts, and to members of the Analytical, Physical-Chemical, and Physics Section for making the physical tests on the fibers and yarns. Thanks are also due the Cotton Fiber Section for special assistance including Stelometer tests for fiber strength and cross-sectional photomicrographs. Special acknowledgment is made to the Cotton Chemical Processing Section for performing and evaluating the mercerizing and dyeing tests.

Literature Cited

1. Am. Soc. Testing Materials, Com. D-13, "ASTM Standards on Textile Materials (with Related Information)," D180–52T, D414–54T, D1441–8 (54T) and Appendix VII (1954).
2. Bogdan, J. F., and Feng, I. Y. T., "Neps . . . and How to Control Them," *Textile World* **102**, 91–106 (1952).
3. Johnson, B., "Commercial Spinning Tests on Pima S-1," TEXTILE RESEARCH JOURNAL **25**, 396 (1955).
4. Rusca, R. A., "Conversion of the Saco-Lowell Sliver Tester to Electrical Recording," TEXTILE RESEARCH JOURNAL **20**, 780–786 (1950).
5. U. S. Dept. of Agriculture, Agricultural Research Service, Southern Utilization Research Branch, CA-25 (February 18, 1954).

The Effect of an Excessive Gin-Drying Temperature of Cotton on Yarn Quality and Mill Processing

W. J. Hart,[1] T. L. W. Bailey, Jr., William R. Keyser, Jr., and Jack Compton

Institute of Textile Technology, Charlottesville, Virginia

IT HAS long been recognized that the moisture content of seed cotton is a major factor in the ginning process. During the years 1926 to 1929, the U. S. Department of Agriculture developed the first practical artificial seed-cotton driers and demonstrated that their use leads to more efficient ginning and higher cotton grades [1]. Because the increasing use of mechanical pickers for the harvesting of cotton accentuated the problem of cleaning cotton, and because of the desire of the farmer and ginner to produce higher cotton-lint [8] and cotton-seed [11] grades, respectively, the use of such driers has increased in recent years so that at the present time [2, 9] it is estimated that 80 to 90% of the cotton ginned in the United States passes through gin seed-cotton driers [2, 5].

The belief has long been widely prevalent among mill operators that the drying of seed cotton is being carried to excess by the ginner. It has been indicated that heating and drying cotton at temperatures over 200°F can cause changes in the cotton fiber which lead to difficulty in mill processing, increased production cost, and inferior cotton products [4, 5, 6, 7].

The 17-Mill Test [10] was concerned with a large-scale investigation of the effects of various mechanical operations and practices in cotton gins upon the spinning characteristics of the fibers, and upon the quality of the finished yarn and fabric [10]. As a result of the findings from this test, as well as the further study of the data from the point of view of mill organization [3], the Technical Advisory Committee of the Institute of Textile Technology approved a full-scale mill study. This project was carried out by four cooperating Institute member mills on cotton of known history, ginned and stored under carefully controlled and observed conditions. Its purpose was to obtain more precise information as to the extent and cost to cotton mills of fiber damage caused by excessive commercial gin drying.

[1] Present address, The Jaunty Fabric Corporation, Poplar and Park Streets, Scranton 9, Pa.

It was proposed that answers to the following questions, of major economic and practical importance, as well as of theoretical interest to the textile industry, would be obtained: (1) Does overheating of cotton during gin-drying adversely affect mill processing? (2) What is the economic importance of damage caused by overheating of cotton during gin drying, if this is found to occur? (3) What effect has overheating of cotton during gin drying on yarn quality? (4) What changes occur in the cotton fiber as a result of overheating during gin drying?

Harvesting and Ginning of the Test Cottons

The cotton used in this test was grown, harvested, and ginned on the plantation of Richard Leatherman, Jr., Robinsonville, Mississippi. The gin layout is shown in Figure 1. Four treatments were used, as shown in Table I, namely:

No Heat. Gin-drying equipment not in operation during ginning: 25 bales.

Low Heat. Gin-drying equipment adjusted to minimum burner operation: 25 bales.

High Heat. Gin-drying equipment adjusted to maximum burner operation: 25 bales.

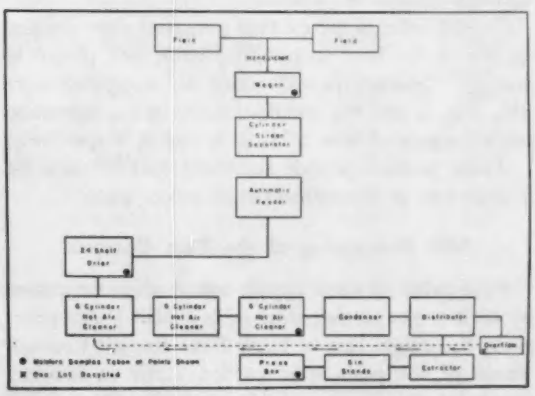


Fig. 1. Flow sheet of seed-cotton processing from field to baled lint.

TABLE I. Test Bales Preparation

Treatment	No. Bales	Max. Drying Temp. (°F)	Drying Time (sec)
No Heat	25	—	—
Low Heat	25	176	90
High Heat	25	367	90
High Heat Recycled	1	367	180

TABLE II. Effect of Gin Drying on Spinning Performance (EDTSH)* in Four Cotton Mills

Mill No.	1	2	3	4
Yarn type and Count	Carded 37's Filling	Carded 30's Warp	Combed 40's Filling	Carded 35's Filling
Treatment				
No Heat	34.1	17.7	14.6	19.9
Low Heat	39.6	20.3	16.8	24.8
High Heat	44.7	28.1	21.0	25.2
High Heat Recycled	65.1	—	—	—

* Ends down per thousand spindle hours.

TABLE III. Weaving Performance of Gin-Dried Test Cotton Yarns in Two Cotton Mills

Treatment	Loom Stops per Hour	
	Mill 1*	Mill 2†
No Heat	0.76	0.166
Low Heat	0.84	0.262
High Heat	0.84	0.269
High Heat Recycled	0.97	—

* All loom stops. Test cottons: 37's filling yarn.
† Warp stops only. Test cottons: 30's warp yarns.

High Heat, Recycled. Gin-drier burners set at maximum capacity and the seed cotton passed twice through the driers: 1 bale.

The 76 bales of cotton thus prepared were shipped to one of the four cooperating mills, and placed in storage. Storage periods prior to processing were 2½, 3½, 4, and 4½ months for the four cooperating mills designated here as 1, 2, 3, and 4, respectively.

These storage periods simulated mill practice for a large part of the annual cotton crop.

Mill Processing of the Test Cottons

Five bales of each lot of cotton were processed by each of the participating mills. Mill 1 also processed the single bale of High Heat Recycled cotton. Three of the mills spun carded yarns in nominal counts of 30's warp and 35's and 37's filling yarn, respectively, whereas one of the mills spun combed filling yarn of a nominal 40's count. Five-pound samples of the cottons subjected to the four gin-drying treatments were also sent to the U. S. Department of Agriculture Spinning Laboratory, Clemson College, Clemson, South Carolina. These samples were spun into 22's, 36's, and 40's carded yarns.

Results and Conclusions Drawn from Mill Test Data

Processing Cost Data for Spinning and Weaving of Test Cottons

The processing cost data for spinning and weaving were furnished by Mill 1. The processing in each mill was carried out under the supervision of Institute personnel. Adequate samples were obtained at all stages of mill processing for a complete study of the effect of gin drying of cotton on waste composition and fiber and yarn properties.

Answers to Questions concerning Mill Processing of Test Cottons

1. *Does overheating of cotton during gin drying affect mill processing?* The effect of overheating during gin drying on subsequent spinning performance is shown in Table II.

In each of the four mills, ends down per thousand spindle hours (EDTSH) during spinning showed a significant increase as the cotton was heated more intensively during gin drying.

Two of the mills furnished data on weaving performance, as shown in Table III. Loom stop rates increased with the severity of heating of cotton during gin drying. This was true for both the warp and filling yarns.

The total mill waste should be largely dependent upon the residual trash in the cotton after ginning. Such trash is generally reflected in the grade of the cotton and the percentage of mill waste; i.e., the grade goes down and the mill waste goes up. Less cleaning of seed cotton at the gin when using "No Heat" would be expected to leave more trash in the lint, resulting in more mill waste. This was found to be the case from the analysis of the waste obtained from the four mills processing the cottons gin dried under various conditions. This is in agreement with the waste studies made in the 17-Mill Test [10].

TABLE IV. Effect of Gin Drying of Cotton on the Percentage of Comber Noils, Mill 3

	No Heat	Low Heat	High Heat
Comber noils (%)	11.2	14.7	16.0

A significant increase of comber noils with increasing drying temperatures occurred in Mill 3, producing combed yarn; see Table IV.

The processes affected were found to vary from mill to mill, and to different degrees. But it will be observed that it is usually in the later, and consequently the more expensive, stages of processing, where the damage to cotton makes itself more evident.

The answer to the question whether cotton can be gin dried to the extent that mill processing is adversely affected is thus an unqualified *"Yes."*

2. *What is the economic importance of damage caused by overheating of cotton during gin drying?* Comparative cost data were furnished by only one of the participating mills. In this case, there was a differential of $200,000 annually for spinners' and weavers' costs alone between the No Heat and High Heat Recycled ginned cotton. Mill management, in this case, estimated an overall differential of no less than $300,000 annually in processing cost between the two extremes, or about $10 per bale of cotton processed. Although this represents the maximum processing loss that would probably be incurred as a result of the use of excessive gin-drying temperatures, significant losses occur at the intermediate gin-drying temperatures that cannot well be ignored.

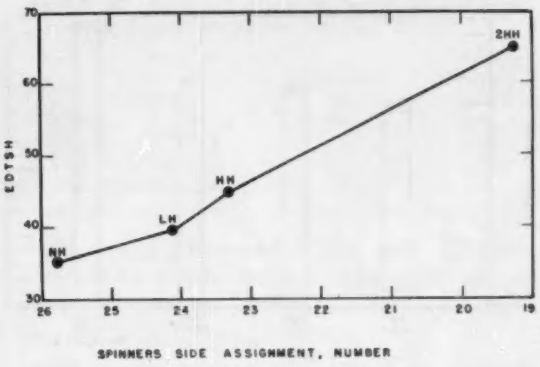


Fig. 2. Effect of various gin-drying conditions of cotton on the relationship of the spinner's side assignment versus ends down per thousand spindle hours during spinning of 37's carded filling yarn.

As previously pointed out (see Table IV) the increase of comber noils produced due to overheating of seed cotton during gin-drying makes this a more expensive operation than usual.

The spinner's side assignment, Table V and Figure 2, shows decreasing sides per attendant with increasing EDTSH. The corresponding increase in cost is given in Table V and illustrated graphically in Figure 3, as spinner's cost per pound of yarn.

Again from Mill 1, the relationship between weaver's loom assignment and loom stops per hour

TABLE V. Spinning and Weaving Cost Data Obtained on Test Cottons * Gin Dried under Various Conditions, Mill 1

		Gin-Drying Condition			
	Mill Standard	No Heat	Low Heat	High Heat	High Heat Recycled
Spinner's assignment, sides†	22	25.8	24.1	23.4	19.3
Spinner's cost (cents per pound of yarn)‡	—	2.43	2.53	2.61	3.09
Weaver's assignment, looms§	50	80	73	72	63
Loom stops per hour‖	—	0.76	0.84	0.84	0.97
Weaver's cost (cents per pound of cloth)¶	—	3.00	3.28	3.33	3.80
Waste cost (cents per pound of cloth)					
Opening and picking	—	0.32	0.31	0.26	0.29
Carding	—	1.04	1.06	1.09	1.47
Total	—	1.36	1.37	1.35	1.76

* Work loads for test cottons are theoretical maximum figures, determined from job studies. Mills normally use about 80% of this figure.

† Filling, 136 spindles per side; warp, 110 spindles per side.

‡ Spinner's cost only. Does not include doffers, supervision, overhead, etc.

§ Based on 39 in., 80×80, 4.00 print cloth.

‖ All loom stops, warp and filling. Looms stop on all filling breaks.

¶ Weaver's cost only. Does not include loom fixers, battery fillers, overhead, etc.

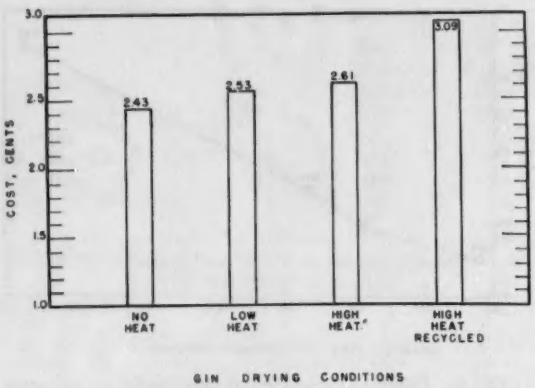


Fig. 3. Effect of various gin-drying conditions of cotton on the spinner's cost per pound of 37's carded filling yarn.

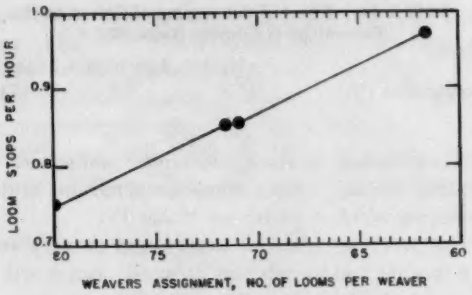


Fig. 4. Effect of various gin-drying conditions of cotton on the weaver's loom assignment versus loom stops per hour relationship for filling yarns in 39-in., 80 × 80, 4.00 print cloth.

is shown in Table V and Figure 4. The corresponding increase in cost is given in Table V and illustrated graphically in Figure 5, as weaver's cost per pound of cloth.

3. *What effect has overheating on yarn quality?* Although there are many ways to grade the quality of yarn, the authors chose to use break factor and the per cent nonuniformity at 10-ft sensitive length, using the Brush Uniformity Analyser as the primary criteria.

The yarn quality of the yarns spun at the U. S. Department of Agriculture Spinning Laboratory, Clemson, South Carolina, from the various gin-dried cottons is shown in Table VI. It will be noted that the break factor decreases for each yarn size spun with increasing severity of gin drying. The per cent nonuniformity also has a slight tendency to increase as the severity of gin drying increases.

Similar results were obtained from the yarns spun in the four cooperating mills (see Table VII) in that the yarn break factors decreased and the per cent nonuniformities increased with increasing gin-drying temperatures.

TABLE VI. Effect of Gin-Drying Conditions on the Quality of Test Yarns Spun at the U. S. Dept. of Agriculture Spinning Laboratory, Clemson, S. C.

Yarn Property	Yarn Count	Gin-Drying Conditions			
		No Heat	Low Heat	High Heat	High Heat Recycled
BF*	22's	2840	2785	2735	2651
BF	36's	2563	2484	2437	2311
BF	40's	2440	2400	2320	2240
% NU†	40's	99.7	103.6	107.2	103.8

* Corrected break factor, product of skein strength and yarn count.
† Per cent nonuniformity at 10-ft sensitive length, using the Brush Uniformity Analyser.

TABLE VII. Effect of Gin-Drying Conditions on the Quality of Yarns Spun in Four Cotton Mills

Mill No.	1 37's Filling		2 30's Warp		3 40's Filling		4 35's Filling	
Gin Heat Treatment	BF*	% NU*	BF	% NU	BF	% NU	BF	% NU
No Heat	2060	114	2105	104.5	2270	86.5	2100	108.0
Low Heat	1950	119	2078	104.5	2265	86.0	1904	118.4
High Heat	1922	120	1958	109.0	2109	89.9	1876	118.2
High Heat Recycled	1765	125	—	—	—	—	—	—

* See footnotes to Table VI.

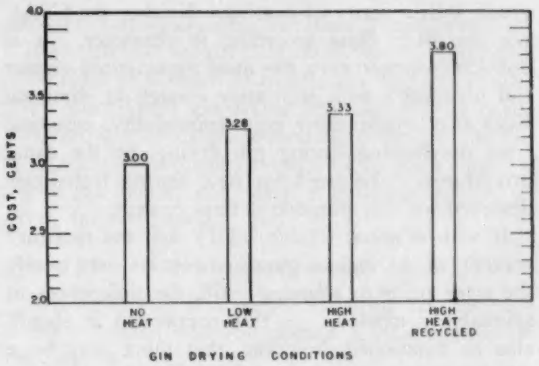


Fig. 5. Effect of various gin-drying conditions of cotton on the weaver's cost per pound, based on filling yarn loom stops of 39-in., 80 × 80, 4.00 print cloth.

Independent ranking of the coded yarns and fabric from Mill 3 by use of yarn appearance board and cloth appearance ratings, respectively, led to the following statements from this mill:

From an evenness standpoint "High Heat" was definitely the more uneven and "No Heat" and "Low Heat" yarns were very nearly the same. From a nep standpoint, we rated "No Heat," "Low Heat," and "High Heat," with "High Heat" being the neppier.

Some of the yarn was woven as filling in a 76 × 64 construction, with a medium blue warp, and from an evenness and nep standpoint, the cloth was graded identical to the appearance boards.

It will be noted that a definite trend toward increasing neppiness in yarns with increasing severity of gin drying was found in this mill. However, there was no definite increase in neppiness of card webs. These findings confirm the conclusions drawn from the 17-Mill Test [10]:

There was an increase in the number of ends down, and while there was no increase in the nep count in card webs, there was an increase in neps in dyed cloth.

TABLE VIII. Moisture Content at Various Processing Points of Cotton Gin Dried under Various Conditions

Mill No.	Gin-Drying Treatment	Moisture Content (%) Gin Press Box	Stored Bales	Lap	Card Sliver
1	No Heat	6.1	5.46	5.34	6.91
	Low Heat	4.3	5.61	5.23	6.89
	High Heat	2.7	5.18	4.87	6.76
	High Heat Recycled	1.6	4.65	—	6.51
2	No Heat	6.1	5.94	6.45	5.51
	Low Heat	4.3	5.73	6.17	5.62
	High Heat	2.7	4.99	5.04	5.18
3	No Heat	6.1	5.93	5.14	4.80
	Low Heat	4.3	5.42	4.86	4.76
	High Heat	2.7	5.12	4.75	—
4	No Heat	6.1	5.71	5.60	5.60
	Low Heat	4.3	5.34	5.12	5.58
	High Heat	2.7	5.26	4.42	5.15

TABLE IX. Effect of Various Gin-Drying Conditions on the Single-Cotton-Fiber Breaking Strength

Treatment	Elongation (%)	Breaking Strength (gm)
No Heat	9.1	4.90
Low Heat	7.2	4.02
High Heat	7.1	3.74
High Heat Recycled	7.2	3.94

4. *What changes occur in the cotton fiber as a result of overheating during gin drying?* First, it should be noted that the moisture content of the cotton at the gin press box decreases as the severity of the gin-drying conditions increase, as would be expected; see Table VIII. After the cotton lies in storage for several months and proceeds through the mill following opening, the moisture lost during gin drying is largely regained (Table VIII), prior to spinning. It becomes evident that another, or several, physical properties of the cotton fiber must be affected by overheating in the gin, and that overdrying alone is not responsible for poor spinning performance observed in the mills.

In a sample dyeing of the test filling yarn of all four ginning conditions woven into a common warp, a differential dyeing effect was observed. With Pontamine Sky Blue 6 BX Greenish Conc. 150%, the increase of heat during gin drying caused progressively poor dye receptivity. Indiscriminate mixing of variously gin-dried cottons can thus lead to warp and filling streaks in dyed, finished cotton fabrics.

The Pressley Fiber Bundle Strength Test showed no loss of tensile strength as a result of the various gin-drying conditions, although single-fiber breaking strength decreased with increasing severity of gin drying. See Table IX.

It will be noticed in Table IX that the greatest difference in strength was found between No Heat and Low Heat test cottons—indicating that even a low ginning temperature affects this physical fiber property.

The 5-bale averages of Micronaire fineness, Table X, indicate that no significant differences existed among the various test samples.

TABLE X. Micronaire Fineness of Various Gin-Dried Test Cottons

	Micronaire Fineness (mg/in.)			
Mill No.	1	2	3	4
Treatment				
No Heat	4.1	4.1	4.1	4.1
Low Heat	4.1	3.9	4.0	4.0
High Heat	4.0	4.0	4.0	4.0
High Heat Recycled	4.1	—	—	—

A significant increase in fiber drag in sliver form with increasing severity of gin drying was found, values of 3.38 to 4.02 lb/g representing the extremes of No Heat and High Heat Recycled, respectively.

Some of the difficulties that may be encountered in the preselection of cottons, so as to acquire only bales that have not been overheated during gin drying, may be envisioned from the various fiber test results obtained. It will be noted from the classers' reports summarized in Table XI that there is a tendency to upgrade cotton that has actually been damaged during gin drying. Four professional cotton buyers, the Cotton States Arbitration Board, Atlanta, Georgia, and the Board of Cotton Examiners, Washington, D. C., classed the No Heat, Low Heat, and High Heat gin-dried bale samples. The slight loss of staple length and character detected was more than counterbalanced by an increase of grade with severity of heating. Neither the CSAB nor the BCE class according to character. It is doubtful whether even the most experienced classer can preselect cotton accurately enough to eliminate bales that would show poor spinnability, resulting from overheating during gin drying, by the usual procedures. The need for new testing techniques designed for this purpose is thus evident.

It will be noted (Table VIII) that the moisture contents of the various gin-dried cottons were nearly the same prior to spinning; still, the differences in spinnability existed. In this connection it should also be mentioned, however, that there may be a relation between overheating cotton during gin drying and processing difficulties encountered with "new-crop cotton." It is known that mills which maintain a large inventory and process no bales which have been less than 3 or 4 months in storage have much less difficulty each year with "new-crop cotton" than mills which operate on a small inventory and put "new-crop cotton" into the production line a comparatively short time after ginning. This possible relationship is being further investigated.

In conclusion, it should be stated that this program was not initiated for determining the ideal gin-drying temperature, but rather to determine the effect of extremes of gin-drying conditions on subsequent mill processing and yarn quality. While recycling of cotton, particularly at the higher temperature em-

TABLE XI. Effects of Gin Drying of Cotton on Fiber Classing

	T	B	F	H	CSAB	BCE	Ave.
I. *Grade*							
No Heat	2.18	2.25	2.15	2.05	1.88	2.25	2.13
Low Heat	2.00	1.78	1.96	1.83	1.85	2.08	1.92
High Heat	1.91	1.53	1.86	1.60	1.70	1.95	1.76
II. *Staple*							
No Heat	1.48	1.35	1.50	1.50	1.45	2.70	1.66
Low Heat	2.35	2.25	2.30	2.10	2.15	3.05	2.37
High Heat	2.13	2.00	2.43	2.28	2.25	3.00	2.35
III. *Character*							
No Heat	2.05	1.55	2.10	2.15	—	—	1.96
Low Heat	2.95	2.45	2.70	2.60	—	—	2.68
High Heat	2.75	2.35	3.05	2.65	—	—	2.70

Codes

Grade:	SM = 1.00	*Staple:*	1⅛ = 0.00	*Character:*	Excellent = 1
	MB = 1.50		1 3/32 = 1.00		Good = 2
	M = 2.00		1 1/16 = 2.00		Fair = 3
	SLB = 2.50		1 1/32 = 3.00		Poor = 4
	SLM = 3.00		1 = 4.00		

T, B, F, H = commercial classers.
CSAB = Cotton States Arbitration Board, Atlanta, Georgia.
BCE = Board of Cotton Examiners, Washington, D. C.

ployed in this study, is not the usual ginning practice, it is known that a portion of the cotton in most bales is recycled as a result of overflow at the gin stands. Even when lower gin-drying temperatures are used, this cotton may cause processing difficulties in the mill, a high coefficient of variation in yarn count, a low break factor, and warp and filling streaks in dyed, finished goods.

Acknowledgments

It is a pleasure to make the following acknowledgments to those who contributed to the success of this project:

The Board of Trustees and Technical Advisory Committee of the Institute for approval of the project and permission to publish the findings of this study.

Each of the four Institute member mills in which the gin-dried cotton was processed, and without whose enthusiastic cooperation the study could not have been made.

Mr. Richard Leatherman, Jr., Robinsonville, Mississippi, on whose plantation the cotton was grown, harvested, and ginned, for his helpful advice and able cooperation.

Mr. R. H. Tuttle, Fieldcrest Mills, Project Advisor for the Institute Technical Advisory Committee, and to other members of this Committee, including Mr. Walter Regnery of Joanna Cotton Mills, Mr. Harry Defore of Deering Milliken Cotton Department, and Mr. C. H. Reynolds, Spindale Mills, for special assistance.

Literature Cited

1. Bennett, C. A., "Recent Experiments in Drying Seed Cotton," *Agr. Eng.* **10**, 10, 309 (1929).
2. Brooks, E. H., Continental Gin Company, private communication.
3. Dougherty, J. E., Hance, L. H., and Martin, W. H., "The Relation of Mill Processing Conditions to Yarn and Fabric Properties; a Study of the 17-Mill Test Data Obtained on 1950 Crop," *Textile Inds.* **116**, 111 (1952).
4. Gerdes, F. L., "Cotton Lint Cleaning at Gins—An Evaluation from the Standpoint of Cotton Quality and Economic Factors," U. S. Production and Marketing Administration, Cotton Branch (May 1951).
5. Gerdes, F. L., Rusca, R. A., Stedronsky, V. L., "Drying of Seed Cotton at Gins," U. S. Agricultural Marketing Service and Bureau of Agricultural Chemistry and Engineering (September 1941).
6. Gerdes, F. L., Martin, W. J., Bennett, C. A., "Drying Seed Cotton," *U. S. Dept. Agriculture Leaflet* 181 (1939).
7. Gerdes, F. L., "The Economics of Cotton Ginning," *Cotton Gin & Oil Mill Press* **52**, 11 (1950).
8. Gerdes, F. L., and Bennett, C. A., "Effect of Artificially Drying Seed Cotton Before Ginning on Certain Quality Elements of the Lint and Seed and on the Operation of the Gin Stand," *U. S. Dept. Agriculture Tech. Bull.* 508 (1936).
9. Griffin, A. C., and Merkel, C. M., "Moisture Content of Seed Cotton in Relation to Cleaning and Ginning Efficiency and Lint Quality," U. S. Production and Marketing Administration, Cotton Branch (September 1953).
10. National Cotton Council of America, "Cotton Fiber Properties, Spinning Efficiency Fabric Quality as Affected by Ginning Practices," Memphis, Tenn. (March 31, 1952).
11. Ross, J. E., Jr., "Some Economic Considerations in Equipping and Operating Cotton Gins," U. S. Production and Marketing Administration, Cotton Branch, paper presented at the annual meeting of Alabama Cotton Ginners' Association, Huntsville, Ala. (February 6, 1950).

Cotton Fiber Length Distribution— An Important Quality Factor[1]

Helmut Wakeham

Textile Research Institute, Princeton, New Jersey

Abstract

Recent cotton processing studies conducted by Textile Research Institute have demonstrated that the presence of a large number of short fibers in cotton causes appreciable increases in processing wastes, excessively uneven rovings and yarns, less efficient spinning, and weaker yarns than would otherwise be expected. The present paper outlines various methods of measuring fiber length distribution and of indicating excessive quantities of short fibers in the sample.

Four case histories demonstrating the inferior quality of cottons containing excessive quantities of short fibers are described. These show the effects of improper drying prior to ginning, overprocessing during cleaning, and microbiological attack (cavitoma). In all cases the importance of fiber length distribution as a cotton quality factor is emphasized.

COTTON fiber length has been recognized as a quality factor for so long, and given so much attention in the past, that textile technologists are apt to assume that knowledge of this subject is complete. Present measures of fiber length are believed to provide indexes precise enough to distinguish between samples with different processing behavior. When the length indexes fail to indicate the observed quality differences, other factors such as fineness, mechanical properties, the age of the cotton, and that convenient catchall, "character," are usually blamed.

Studies at Textile Research Institute of these "other" factors have brought to light several instances in which the differences in fiber length were clearly responsible for inferior processing and yarn quality. In some of these instances the conventional length indexes would not have indicated the inferior cotton quality experienced in the processing and laboratory tests. The purpose of this paper is to pass these observations on to cotton technologists who may find them helpful in meeting practical problems encountered in manufacture. After a few preliminary definitions four actual case histories will be described to emphasize the importance of fiber length distribution as a quality factor.

[1] This paper is a summary of recent findings in Textile Research Institute's Cotton Research Project, which is sponsored by the following member companies: The American Thread Co., Anderson Clayton and Co., Bates Manufacturing Co., Coates and Clark, Inc., Cone Mills Corp., Dan River Mills, Deering Milliken Research Trust, Fabric Research Laboratories, Inc., Harris Research Laboratories, Joanna Cotton Mills Co., Johnson and Johnson, Inc., Pepperell Manufacturing Co., Standard Chemical Products, Inc., J. P. Stevens and Co., Inc., West Point Manufacturing Co., U. S. Rubber Co., and U. S. Testing Co.

Fiber Length Criteria

Cotton fibers, as they grow on the cotton seed, are remarkably uniform in length, as indicated by the length array in Figure 1. This length is indicated by the classer's staple length, the upper-half mean length from the Fibrograph, and the upper-quartile length from the fiber length array. All these measures give values which are about equal to the average length of fibers on the seed. These measures are very useful in processing since they indicate length of the longest fibers in the sample arriving at the mill. The roll settings in various drafting and combing operations all depend on the length of these longest fibers.

The bale cotton, however, contains many more short fibers than the seed cotton because of the extensive fiber breakage occurring in ginning. The difference between seed cotton and bale cotton in this respect is also shown in Figure 1. The quantities of these short fibers are not indicated by the staple length or the upper-quartile length; neither

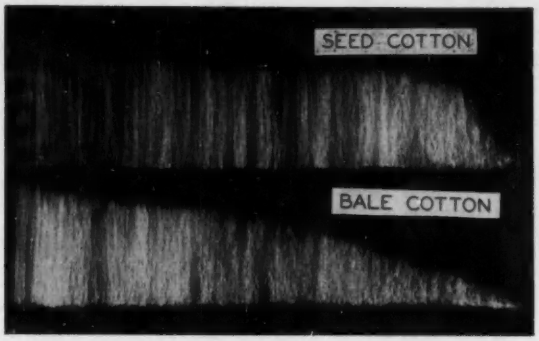


Fig. 1. Photograph of fiber length arrays from seed and bale cotton from the same source.

are they important to machine settings in the mill. They are, therefore, generally ignored in cotton quality considerations. Yet these short fibers are important factors in waste production, spinning efficiency, and roving and yarn evenness and strength, as will be shown later.

What criteria are available for evaluating these short fibers in the bale and later processing stages? Fibrograph and length array methods also give a mean length measurement. This index is somewhat more sensitive to the short fibers in the sample than the upper-half mean. The ratio of upper-half mean to mean length expressed as a uniformity ratio in per cent and the coefficient of variation from a length array also give some indication of the relative amounts of long and short fibers present. If the distribution of fiber lengths in the bale was approximately normal like that on the seed, these criteria would be sufficiently informative to meet many practical requirements. Actually, because each fiber broken in ginning makes at least two short ones, the situation in the bale is far from normal and the indexes of mean length and coefficient of variation are relatively insensitive guides to the short fibers in the sample. To understand this situation fully some consideration must be given to the complete distribution of fiber lengths which may occur.

Weight-Length and Number-Length Distributions

In the conventional fiber length array the fibers are sorted into common length groups, which are then weighed. The weight fraction of each length group plotted against the length of the group gives a weight-length distribution such as that shown in Figure 2. If, however, the number of fibers in each length group is determined by counting or by dividing the group weight by the fiber weight, and then the number fraction of each length group is plotted against length, a number-length distribution is obtained. This distribution may also be obtained directly from the weight-length distribution by multiplying the weight fraction by the fiber weight. If we may assume individual fiber weight is proportional to fiber length the latter may be substituted for the former, making the conversion relatively simple.

It can be seen that number-length plots tend to emphasize the short fibers in the sample, whereas weight-length plots tend to hide them. Since the present paper is concerned with the effects produced by the short fibers, number-length plots will be employed.

Number-length distributions may be compared either for the same total number of fibers or for the same total weight of fibers. The difference between these two bases is illustrated by the comparisons between seed-cotton and bale-cotton length distributions shown in Figure 3. In the upper portion are plotted the number-length distributions for *equal total weights* of the fiber samples. Below are shown the same distributions plotted for *equal total numbers* of fibers. It will be noted that in the former case those fiber samples containing more long fibers will have lower numbers of fiber at all lengths plotted because of the greater weights contributed by the long fibers.

The large number of short fibers created during ginning is clearly demonstrated in the distributions of Figure 3. All of those in the left-hand shaded area are the result of breaking long fibers indicated

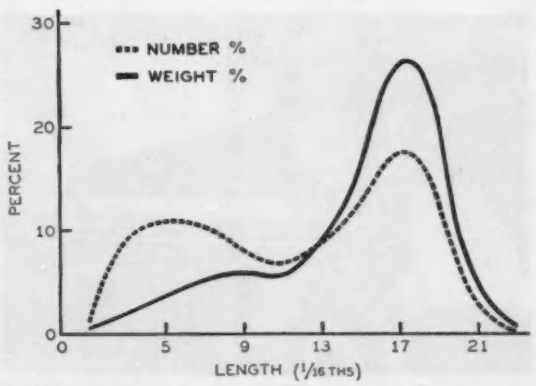


Fig. 2. Number-length and weight-length plots for the same sample of ginned cotton.

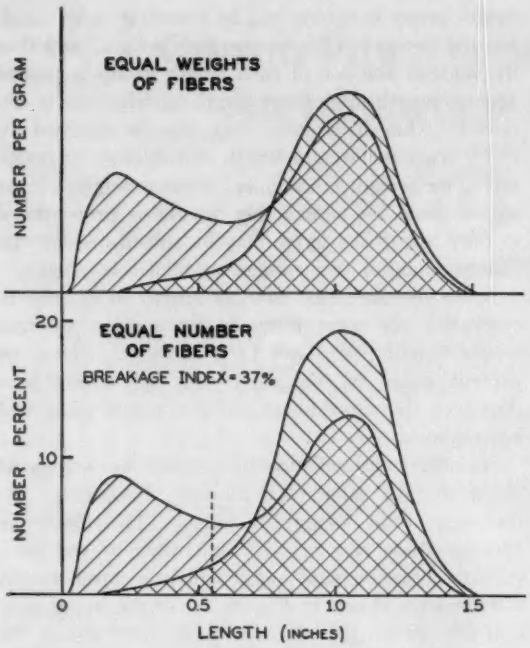


Fig. 3. Number-length distributions for seed and bale cotton from the same source for equal total weights and equal total numbers of fibers.

by the right-hand shaded area. In order to simply indicate the relative deterioration of fiber length a fiber *breakage index,* defined as the ratio of the left-hand shaded area to the sum of the fibers for the bale sample, was set up. This index may be approximated even without knowing the seed-cotton distribution merely by finding the fraction (or per cent) of fibers having lengths less than one-half of the upper-quartile length of the sample. This point is indicated by the vertical line near the middle of the lower plot of Figure 3. With the breakage index it is possible to gage simply the fiber breakage occurring in ginning and subsequent processing.

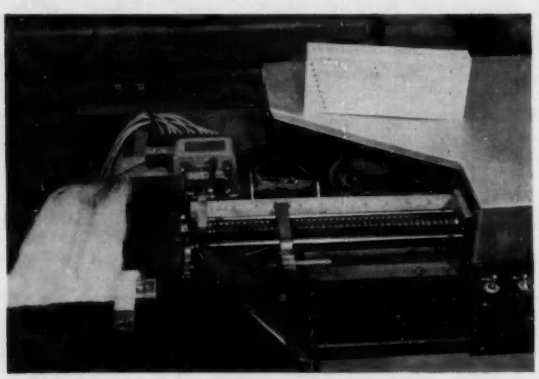


Fig. 4. Textile Research Institute's automatically recording single-fiber length tester.

In the following comparisons the number-length distributions shown will be for equal total weights of fibers since weights are commonly used in textile technology. Since the breakage indexes are based on ratios of numbers of fibers for a given sample, the index value will be the same for both types of number-length distributions.

Single-Fiber Length Measurements

Although it is possible to obtain fiber length distributions from arrays, a more direct method is to make actual measurements of individual fiber lengths on carefully selected samples. This task is not nearly as formidable as it may appear to the uninitiated reader. Textile Research Institute has developed an automatically recording fiber length tester based on the Wool Industries Research Association Length Meter [1]. This instrument will measure fibers as short as 0.2 in. (See Figure 4.) Fibers are divided into groups differing in length by 0.1 in. Accurate mean lengths and rough length distributions may be obtained with as few as 200 fibers if the selection is properly made [2]. The time required is little more than an hour.

Illustrative Examples

The examples cited below have been taken from research studies in Textile Research Institute's Cotton Research Project. In each case a pair of cottons is considered, one with a length distribution definitely inferior to the other. The reader in examining these cases should keep in mind that these are specific examples which may or may not be typical of other cottons bearing the same names.

Case 1. *Ginhot vs. Ginwet*

These two samples of cotton were prepared in a study of the effects of overdrying prior to ginning on cotton quality [4]. The seed cottons originated in the same field and were picked on the same day. The Ginwet portion was passed through two drying towers at atmospheric temperatures and then fed directly into the gin stand at a moisture content of

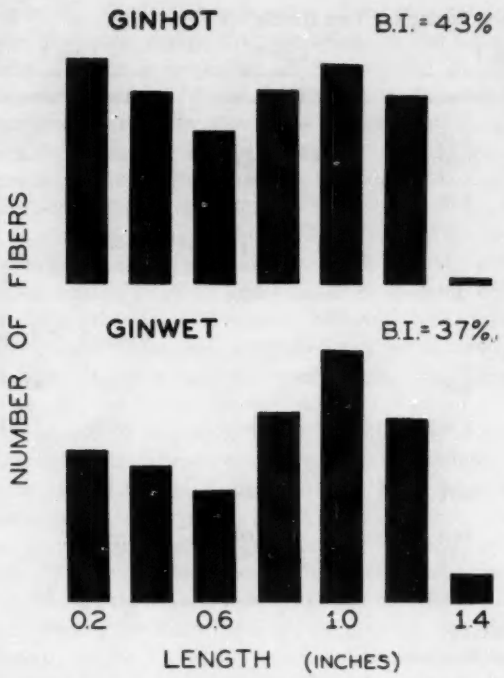


Fig. 5. Number-length distributions for Ginhot and Ginwet samples.

6% in the lint. For the Ginhot sample the input air for the first drying tower was heated to 450°F, the second tower was unheated, and the cotton was introduced into the gin stand with a moisture of only 3.7% in the lint. Two bales of each type were used in the subsequent processing comparison.

None of the several cotton classers who examined these samples was able to tell them apart. A comparison of the conventional fiber properties, however, showed a very small difference in mean fiber length and in uniformity ratio. (See Table I.) The fiber length distributions, furthermore, showed a definitely larger number of short fibers in the Ginhot sample than in the Ginwet. These distributions are shown in Figure 5. The difference between them is clearly indicated by the breakage indexes of 37% and 43% for the Ginwet and Ginhot, respectively.

In the processing experiments, which were performed at Joanna Cotton Mills, the Ginhot sample yielded more waste, weaker and less even rovings and yarns, and 21.4% more ends down in spinning. (See Table II.) A check of the single-fiber properties showed that the cottons were almost identical with respect to their mechanical behavior (Table I). It was therefore concluded that the differences in

TABLE I. Fiber Properties of Cotton Pairs

	Case 1		Case 2		Case 3		Case 4			
							Karnak		Amsak	
	Ginhot	Ginwet	Cayitomic	Rainmed	SL-1H	SL-Bale	Carded	Combed	Carded	Combed
Length Array										
Upper quartile (in.)	1.10	1.12	1.19	1.23	0.98	1.12	1.34	1.38	1.34	1.47
Mean length (in.)	0.91	0.96	0.97	0.99	0.75	0.94	1.00	1.03	1.16	1.21
Coefficient of variation (%)	—	—	32	33	42	28	38	27	37	24
Fineness (μg/in.)	4.59	4.61	4.34	4.30	5.0	4.8	3.50		3.31	
Pressley Strength (1000 psi)	76	78	85.3	83.4	77	79	—		—	
							Combed		Combed	
Single-Fiber Properties										
Cross-sectional area (cm^2)	1.26	1.25	1.24	1.26	1.34	1.37	0.94		0.99×10^{-6}	
Crimp (g/cm^2)	0.72	0.79	0.84	1.02	0.52	1.09	0.54		0.61×10^{3}	
Hookean slope (g/%)	0.55	0.57	0.60	0.59	0.64	0.54	0.58		0.58	
Elastic modulus (g/cm^2 %)	0.48	0.46	0.50	0.50	0.49	0.41	0.64		0.61×10^{6}	
Breaking elongation (%)	8.9	8.5	8.0	8.5	7.2	6.9	7.4		8.7	
Breaking load (g)	4.67	4.43	4.64	4.63	3.92	3.54	4.38		5.30	
Breaking stress (g/cm^2)	3.80	3.63	3.78	3.85	3.04	2.65	4.67		5.08×10^{6}	

TABLE II. Processing Performance, Roving and Yarn Quality

	Case 1		Case 2		Case 3		Case 4	
	Ginhot	Ginwet	Cavitomic	Rainmed	SL-1H	SL-Bale	Karnak	Amsak
Processing Wastes								
Opening (%)	0.22	0.22	2.48	1.16	—	—	—	—
Picker (%)	1.56	1.71	1.07	0.43	9.5	6.0	—	—
Carding (%)	3.96	3.80	6.87	6.61	9.5	6.0	—	—
Total (%)	5.74	5.73	10.42	8.20	—	—	—	—
Neps/grain at card	16.1	16.8	—	—	121	11	—	—
Spinning (EDPTSH*)	31.8	26.2	78	50	Very high	Low	—	—
							Combed	Combed
Roving								
Count	2.10	2.10	2.00	2.00	—	—	4.00	4.00
Strength (g)	166	250	98	121	—	—	19	32
Evenness (%)	30.3†	30.3†	8.42‡	8.28‡	—	—	3.25§	2.66§
Yarn								
Count	39/1	39/1	36/1	36/1	36/1	36/1	—	—
Strength								
Skein (lb)	54.5	57.5	53.9	58.3	35	60	—	—
Single end (g)	193	211	193	217	—	—	—	—
Linear Unevenness (%)	4.58§	4.31§	19.4†	18.6†	12.0§	8.3§	—	—

* Ends down per thousand spindle hours. † Brush nonuniformity.
‡ Uster Linear Unevenness. § Fielden Linear Unevenness.

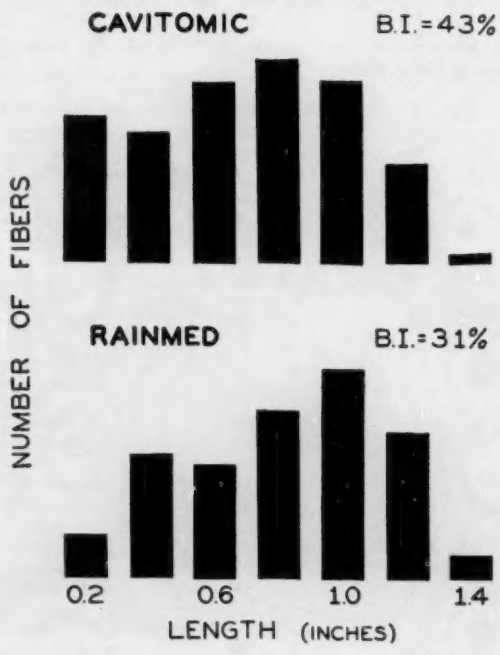


Fig. 6. Number-length distributions for Cavitomic and Rainmed samples.

processing behavior were most probably due to the difference in fiber length distribution, a difference which was not indicated by either the upper-half mean length or the uniformity ratio.

Case 2. Cavitomic vs. Rainmed

In a study [5] of the differences between raingrown and irrigated cottons it was found that 3 out of 12 bales of the raingrown sample exhibited very pronounced symptoms of the deterioration identified by Hall and Elting [3] of Kendall Cotton Mills as "cavitoma." Cotton from the 3 Cavitomic bales and from the 9 normal raingrown bales, hereinafter identified as "Rainmed," were subsequently studied in a careful laboratory and processing comparison.

In this case all 12 bales were originally purchased as a homogeneous lot after careful selection by cotton classers and from laboratory tests. Again the conventional group-fiber properties showed the cottons to be almost identical in length, strength, and fineness (see Table I). A number-length distribution, however, showed a considerable preponderance of short fibers in the Cavitomic sample with a breakage index of 43%, as compared to 31% for the Rainmed cotton. This difference is illustrated in

Figure 6. Single-fiber properties of the two cottons were the same except that the crimp in the Cavitomic fibers was somewhat lower than that of the Rainmed fibers. All available evidence indicated that this difference in fiber crimp would, if anything, give the Cavitomic sample superior processing performance and yarn quality over the Rainmed. Actually the opposite was found.

In the processing study at Dan River Mills the Cavitomic cotton gave twice as much opening and picker waste (Table I) and 46% more spinning end breakage than the Rainmed. Roving and yarn strengths and evenness characteristics were clearly in favor of the normal Rainmed cotton (see Table II).

It should be emphasized that in both Case 1 and Case 2 similar differences in fiber length distribution were related to the same differences in processing performance and yarn quality. To be sure, the causative factors for the deterioration in length uniformity were not the same. In the overdrying-prior-to-ginning case definite modification of fiber structure contributing to fiber breakage in ginning was detected. In the Cavitomic cotton microbiological influences caused the formation of weak places in the fibers, which resulted in excessive breakage in later processing. But in each instance the effects in yarn manufacture were the same. Both of these examples strongly support the hypothesis that the presence of a large number of short fibers is detrimental to processing facility and yarn quality.

Case 3. SL-1H vs. SL-Bale

In the previous examples the fiber breakage occurred prior to receipt of the cotton by the mill opening room. The present case concerns one in which the length uniformity of the cotton was deliberately ruined by 8 passes through a carding beater [6]. In this instance 1 bale of cotton with a staple length of about $1\frac{1}{16}$ in. and a Micronaire reading of 4.9 was divided into several parts, one of which was processed through a Kirschner beater at the Saco-Lowell Shops. This beater was operated at a speed of 1040 rpm with the blades set at $\frac{3}{32}$ in. from the beater bars. The resulting number-length distributions are shown in Figure 7. Fiber breakage index for the SL-1H was 59%, as compared to 30% for the SL-Bale. This time the conventional group-fiber properties and single-fiber properties indicated rather large differences between the samples (see Table I).

Portions of the original bale and of the beaten cotton were spun into 22's, 36's, and 50's carded yarns at the Clemson Cotton Testing Laboratory. The bale cotton, of course, processed without undue difficulty. The beaten cotton spun very poorly so that the spinner was forced to use lighter travellers and lower spindle speeds to keep up with 16 bobbins. It is not surprising that the yarns of the beaten cotton were extremely weak and uneven (see Table II).

This example afforded an opportunity to confirm the theory that short fibers contribute to yarn unevenness and weakness because they are not uniformly distributed along the yarn. In the drafting operation the short fibers tend to lag behind the long ones, which are under better control, until a "slub" of the short fibers is formed and carried through the front rolls. The short fibers, thus, are responsible for the alternating thick and thin places in the yarn. Both types of places in the SL-1H yarn were tested for fiber length distribution with the results shown in Figure 8. It is fairly evident that the short fibers are concentrating in the thick portions of the yarn.

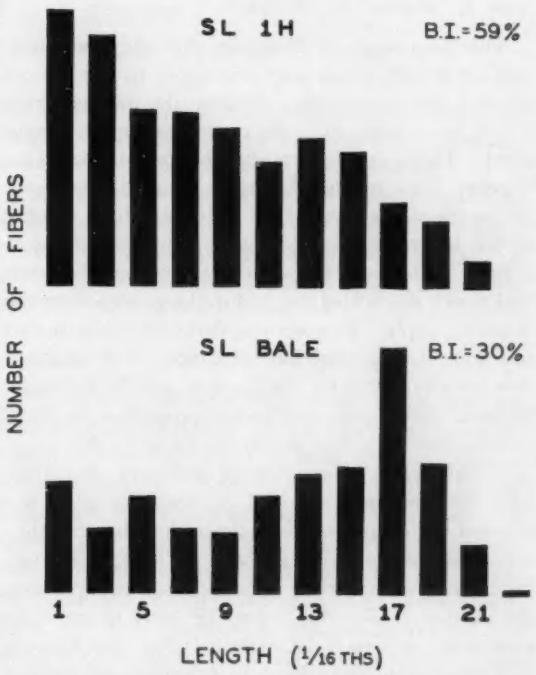


Fig. 7. Number-length distributions for SL-1H and SL-Bale samples.

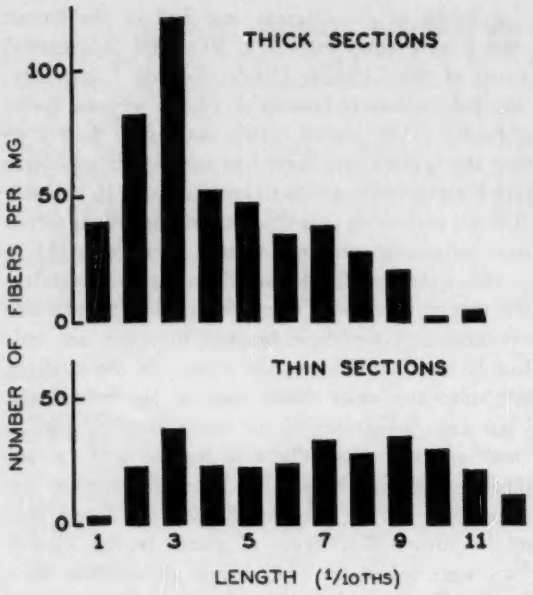


Fig. 8. Number-length distributions for thick and thin sections of 36's carded yarn made from the SL-1H sample.

Case 4. *Karnak vs. Amsak*

This final example illustrates that the generalizations indicated above may also apply to the case of combed fiber assemblies, although the evidence here is not as complete as in the carded examples already cited. These samples were taken from identical production lines in the American Thread Company. Conventional length array determinations of the cotton before combing indicated they were of equal length. After combing, however, the Amsak cotton had fewer short fibers and more long ones than the Karnak sample. Number-length distributions, shown in Figure 9, confirmed this difference. The breakage indexes were 26% for the Karnak and 20% for the Amsak. Single-fiber mechanical properties for these two cottons were very nearly the same (Table I).

While spinning performance and yarn properties have not yet been obtained on these samples, the combed roving properties indicate that they fall into the same pattern outlined above. The Karnak roving is only half as strong and much less uniform than the Amsak (Table II). On the basis of previous experience it would be expected that the Karnak will show more ends down in spinning and weaker and less even yarns than the Amsak. It is hoped that experiments in the near future will confirm these predictions.

Conclusions

The examples cited above have all supported the hypothesis that cotton fiber length distribution is an important quality factor from both the processing facility and yarn quality points of view. Differences in fiber length distribution which seem to account for the differences in cotton quality indicated are not readily detected by measurement of upper-quartile length, length uniformity, or similar measurements now being made in mill or cotton testing laboratories. Part of this failure is due to the practice of considering only weight-length distributions. The general attitude seems to be that the short fibers in the sample, because they do not weigh much, are really not of much importance and hence can be ignored. Apparently they do matter much more than is generally thought, much more than their small weight fraction implies. Number-length distributions or number fractions present the advantage that it is more difficult to ignore the short fibers than it is with weight-length distributions.

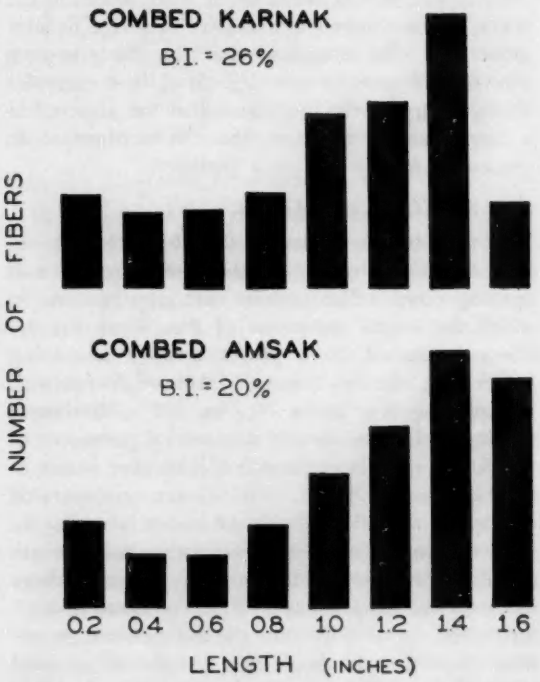


Fig. 9. Number-length distributions for Karnak and Amsak combed rovings.

While number-length distributions may be calculated from length-fineness array data, the use of this method is cumbersome and time consuming and, therefore, unsuited to routine mill testing. Clearly a more efficient method of evaluating the short-fiber content in a cotton is required for adequate cotton quality evaluation. Such methods are now being investigated.

Acknowledgment

Textile Research Institute wishes to express its appreciation to The American Thread Company, Dan River Mills, Inc., Joanna Cotton Mills, and Saco-Lowell Shops for assisting in the processing experiments mentioned above. The author also wishes to thank Warren Milloway and J. C. Whitwell for making available data on Case 3.

Literature Cited

1. Anderson, S. L., and Palmer, R. C., *J. Textile Inst.* **44**, T95–115 (1953).
2. Daniels, H. E., *J. Textile Inst.* **33**, T137–150 (1942).
3. Hall, L. T., and Elting, J. P., TEXTILE RESEARCH JOURNAL **21**, 580–590 (1951).
4. Leitgeb, D. L., and Wakeham, H., TEXTILE RESEARCH JOURNAL **24**, 1047–1057 (1954).
5. Wakeham, H., Stickley, H., and Spicer, N., TEXTILE RESEARCH JOURNAL **24**, 1037–1046 (1954).
6. Whitwell, J. C., Lemiszka, T., and Hughes, V. L., TEXTILE RESEARCH JOURNAL **21**, 556–564 (1951).

Speedar Measurement of Fiber Fineness and Compressibility

K. L. Hertel and C. J. Craven

Agricultural Experiment Station, University of Tennessee, Knoxville, Tennessee

Introduction

The textile industry's interest in cotton fiber fineness and maturity has increased with the advent of rapid instruments using air flow to measure these properties. Operating in an empirical fashion the industry seeks simple correlations between instrument readings and some phase of mill or fabric performance without regard to any scientific significance of the readings. From this standpoint, almost any air-flow measurements give equally good results [1–6]. The sole criterion, then, is the rapidity with which reproducible results are obtained. Although the Arealometer was a sound, rapid instrument for obtaining both fineness and immaturity from which other properties were derivable, a more rapid method giving a single property was widely adopted.

As early as 1935 experiments were carried out at this laboratory to get significant if not precise measurements of fineness without weighing the sample. After successive improvements, a very rapid instrument was built in 1953. The results were encouraging, but the systematic variation in fiber compressibility gave fineness readings modified too much by compressibility to have wide applications. The instrument discussed herein was projected in order to replace a fixed-weight sample by a weighed sample to which the instrument is readily adjusted. Time is saved in the weighing operation, and both fineness and compressibility are obtained. This high-*speed* *A*realometer is called the *Speedar*.

Air-Flow Pattern

The air-flow pattern in the cylinder of the Speedar, shown diagrammatically in Figure 1, has been designed to be independent of the sample size above a certain minimum. Two advantages result. In the first place, the resistance along the flow path will depend only upon the fiber fineness providing the density of packing is held constant, and in the second place, the effect of fiber orientation is minimized since the flow pattern is not unidirectional but changes direction through 180° from one end of the path to the other. In the present Speedar, the minimum layer containing the flow pattern is about ¼ in.

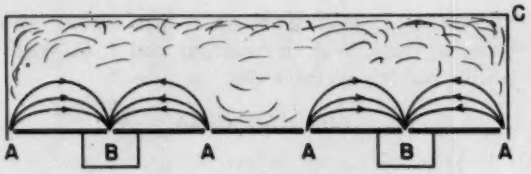


Fig. 1. Air-flow pattern.

thick and represents 5 g of sample. Any amount of fiber above this layer has negligible effect upon the flow pattern. To apply this principle it is necessary only to weigh a selected sample and set the compression mechanism so that the final thickness CA is proportional to the sample weight, resulting in a standard density of packing. After compression, air is drawn in at points A along annular rings by decreasing the air pressure at B. The pressure reduction is less than 1 in. of water. This small change in pressure does not alter the humidity of the flowing air sufficiently to affect the fineness reading. The magnitude of the pressure drop across AB indicates directly the fiber fineness on an appropriately graduated scale. The force to compress the sample to the standard density indicates a property, which has tentatively been designated the packing modulus, on a scale graduated in kilograms per square millimeter. Since the force of compression per square millimeter seems to vary as the cube of the solid-to-void ratio (paper presented to Gordon Research Conference, 1952, and to be published in TEXTILE RESEARCH JOURNAL), the modulus scale reading multiplied by the cube of this ratio, or 0.005, gives the actual force of compression on each square millimeter. The quantity has been called packing modulus because it is directly proportional to the elastic modulus of the fibrous material, all other factors remaining unchanged.

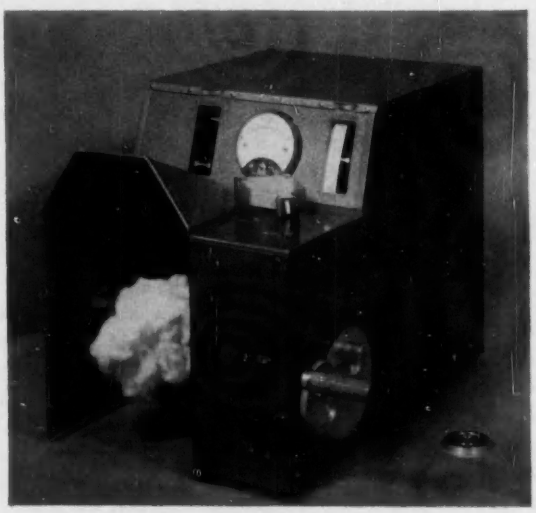


Fig. 2. Photograph of Speedar.

Instrument

An instrument embodying the principles stated above is shown in Figure 2. It consists of two interconnected parts. The weighing part on the left accepts the selected sample and indicates its weight. The compression part is then adjusted to that weight sample, after which the sample is transferred, compressed, and measured.

The essential features of the mechanism are shown diagrammatically in Figure 3. The weighing part is shown in the upper part of the diagram and consists of a simple spring-actuated beam pivoted on the frame. The sample C, caught on special fingers at the end of the beam, depresses the indicator N. A corresponding indicator is brought into coincidence by rotating the cam B on its frame bearing, which in turn rocks the compression linkage about the frame bearing F to bring the piston P to the height appropriate for the sample when compression takes place. Once cam B is adjusted, the sample is placed in the cylinder and lid D closed, after which lever L is pulled up to compress the sample and simultaneously raise air cylinder A. The dead-weight piston which has been supported at the top of the cylinder now falls and draws air through the metering orifice O and the cotton sample to give a pressure difference that indicates the fineness of the fiber on scale E. The force of compression is indicated on M to give the packing modulus. The force of compression shows some decrease with time because of creep. For accurate work, a bypass valve on the air cylinder may be used to time automatically the read-

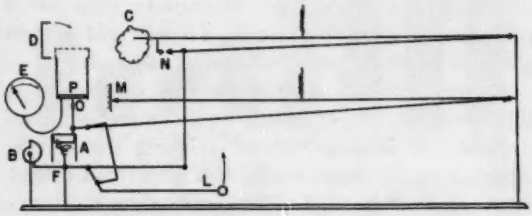


Fig. 3. Diagram of Speedar mechanism.

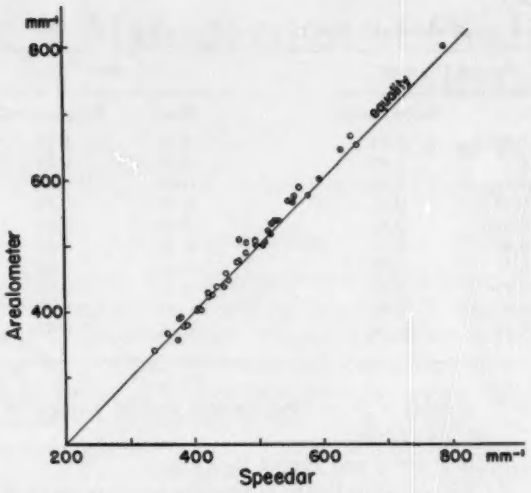


Fig. 4. Arealometer fineness versus Speedar fineness.

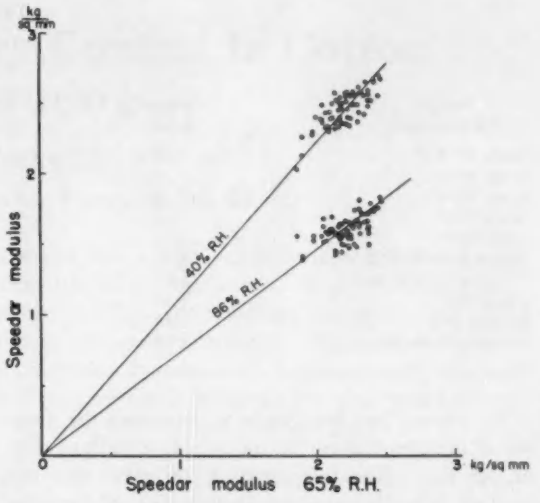


Fig. 5. Speedar packing modulus at 40% and 86% R.H. versus that at 65% R.H.

ing of the modulus. Although the magnification of the force indicating linkage is high, there is some movement of the piston with a change in compressive force. The effect of this motion is to alter slightly the density of the sample and hence the indicated fineness. For very accurate work the fineness may be corrected by multiplying the modulus reading by a factor and adding the product to the indicated fineness. The correction can amount to 1 or 2%.

Results

A series of well-mixed cottons taken from the "Annual Varietal and Environmental Studies" of the 1953 crop, made by the Field Crops Research Branch, U. S. Department of Agriculture, have been measured by the Speedar and by the Arealometer. The results are plotted in Figure 4, together with results from several other cottons selected to give a wide range in fineness. The correlation coefficient between Arealometer and Speedar readings is 0.983. These cottons were measured at relative humidities of 40, 65, and 86%. The overall average finenesses were 468.6, 470.3, and 471.7 mm^{-1}, respectively. The modulus readings at 40 and 86% R.H. are plotted against those at 65% R.H. in Figure 5. Changes in humidity caused a large change in modulus, but only a small change in fineness readings, which was in a direction opposite to what one would expect from the swelling of fibers at high humidity. It would seem likely, therefore, that frame distortion plus piston movement for modulus indication tends to compensate, or overcompensate, for change in fineness due to change in humidity.

The economic importance of packing modulus is unknown. It did seem worth while, however, to obtain its measurement since it could be done with little effort and the property does vary among cottons and with their treatment. Table I gives modulus values for 10 cottons selected from the "Annual Varietal and Environmental Studies" of the 1952 crop made by the Field Crops Research Branch, U. S. Department of Agriculture. The first 5 cottons were grown at State College, New Mexico, the second 5 at Florence, South Carolina. Each cotton was tested in the forms of ginned lint, second drawing, and comber slivers. The sliver samples were retested after being fluffed up and randomized with combs. Each value in Table I is the mean of 10 determinations. It will be noted that there is a difference between cottons, between the ginned lint and second drawing sliver of the same cotton, and between the parallelized and randomized states of the sliver samples. From these and other similar data it appears that the packing modulus depends upon the cotton, its relative humidity, the parallelism of the fibers, the amount of crimp, and possibly the maturity.

TABLE I

Sample Identification	Ginned Lint	Modulus (kg/mm²) Second Drawing Sliver	Second Drawing Randomized	Comber Sliver	Comber Randomized
Acala 1517-C	2.22	0.53	0.85	0.51	0.77
Acala 9056	2.12	0.55	0.85	0.41	0.70
Acala 9094	2.13	0.55	0.84	0.42	0.75
Acala 9246	2.14	0.55	0.85	0.46	0.74
Acala 8987	2.21	0.62	0.87	0.62	0.69
AHA×C100W-148	1.31	0.45	0.70	0.32	0.55
TH215×C100W-861	1.67	0.52	0.78	0.38	0.68
Coker 100W	1.40	0.47	0.74	0.36	0.66
Sealand 542	1.48	0.47	0.84	0.39	0.66
Earlistaple 50–101	1.53	0.54	0.78	0.35	0.67

No attempt has been made to determine the number of samples that can be measured per unit of time or per day. The instrument is so rapid that the limiting factor is sampling, identification of the samples, and recording of results.

The accumulation of dirt around the orifice and air cylinder caused some difficulty in an earlier model. The present model is so designed as to be fairly insensitive to dirt and trash, and is easily disassembled for cleaning.

The instrument is readily checked. Two 5-g weights are used to check the weighing portion, while a block ½ in. wide by ¼ in. thick is simultaneously used to check the piston height. A 5-g weight on the balance with the piston closed on the ¼-in. block should give indicator coincidence because a 5-g sample is compressed to ¼-in. thickness to give standard density. The 10-g weight should similarly give coincidence when the ½-in. thickness is used.

Any air leak between the standard orifice and the cotton would, of course, affect the fineness reading. An examination for leakage is made by substituting in place of the cotton a check plate containing an orifice of known flow characteristics.

Conclusions

1. The Speedar is a self-contained air-flow instrument using low-pressure differential for measuring the specific area or fineness of fibers without altering the relative humidity surrounding the fiber.

2. It also measures a new property called packing modulus.

3. It tests a 5- to 10-g sample and is insensitive to fiber orientation.

4. It is rapid and simple to operate.

5. The reproducibility of fineness measurements is as good as on other air-flow instruments.

Acknowledgment

The authors wish to thank the Field Crops Research Branch, U. S. Department of Agriculture, for cotton samples taken from the 1952 and 1953 "Annual Varietal and Environmental Studies." Acknowledgment is also due the Swift Manufacturing Company, Columbus, Georgia, for cooperating in an extensive mill test of the Speedar. The authors are indebted to Miss Reba Lawson for all measurements and calculations connected with this paper. This research was supported in part by 9b3 Research and Marketing Administration funds allocated by the Cotton Genetics Technical Committee of the Regional Project S-1, National Cooperative Research in Plant Science for Improvement of Cotton.

Literature Cited

1. Brown, H. M., and Graham, J. S., TEXTILE RESEARCH JOURNAL **20**, 418 (1950).
2. Calkins, E. W. S., TEXTILE RESEARCH JOURNAL **20**, 426 (1950).
3. Elting, J. P., and Barnes, J. C., TEXTILE RESEARCH JOURNAL **18**, 358 (1948).
4. Hertel, K. L., and Craven, C. J., TEXTILE RESEARCH JOURNAL **21**, 765 (1951).
5. Pfeiffenberger, G. W., TEXTILE RESEARCH JOURNAL **16**, 338 (1946).
6. Sullivan, R. R., and Hertel, K. L., *Textile Research* **11**, 30 (1940).

Management of Quality Control in Cotton Manufacturing

Oliver P. Beckwith

Fabric Research Laboratories, Inc., Boston, Massachusetts

Introduction

Since about 1945 great progress has been made in providing tools for improving the control of quality in textile manufacturing. The use of statistical methods in sampling, presenting and interpreting data, and planning production experiments has grown considerably with profitable results. Research effort has contributed instruments for measuring quality characteristics that are quick, accurate, and practical for use under the stringent demands of day-to-day manufacturing. Witness the yarn-evenness testers, fiber-fineness and length- and strength-measuring devices, picker-lap meters, nep-counting techniques, color-measurement devices, and so on. The contributions of technical societies and associations in this period have been great. Organizations such as the National Cotton Council, American Society For Testing Materials, American Society For Quality Control, Textile Research Institute, Institute of Textile Technology, The Fiber Society, and others have made available to the textile industry studies and works which promote the achievement of quality control. They have been catalysts in generating new knowledge about quality control through bringing together people of common interests and stimulating the exchange of ideas and experiences.

With all these new tools and methods available, the question arises: "How can they be used most effectively in the manufacturing organization?" The purpose of this paper is to consider quality control as a management function in which these techniques play a definite and rational part.

Good Management and Good Controls

Basically, good quality performance in a textile plant stems from good management, not from the particular systems or techniques employed. The job of the line organization is to produce the required amount of goods of the right quality at the right time and at the lowest possible cost. It is easy and a temptation for production people to favor quantity and rate over quality. A well-trained, well-managed organization will not do this. When such an organization skillfully employs the quality-control techniques developed since about 1945, considerable benefit accrues. In summary, it can be said that good controls are not a substitute for good management; they are a part of good management.

The Operation of Control

Like other management controls—production, cost, sales, inventory, etc.—the control of quality is a four-step operation consisting of: (1) the setting of standards; (2) measuring conformance to standards; (3) initiating corrective action; (4) planning improvements.

Most of us are familiar with the operation of management controls. Consider, for example, cost-control systems. Standard costs are established for the various operations in a plant. These are arrived at either by taking past experience as a standard or by synthesizing a standard from the measured elements of cost composing an operation. Cost accounting reports of manufacturing costs by department and comparison with the standards constitute measurement of conformance. The plant superintendent initiates action for correction when it is warranted. Chronic above-standard costs require planning and working out methods and procedures for improvement.

Quality control functions in the same manner. However, unlike cost control, it has made good use of statistical techniques in the four steps of the operation.

Quality Control and Statistical Methods

Why does quality control owe so much to the development of statistical techniques? Because, before their use, quality control was primarily inspection in the finishing room, where "seconds" were separated from perfect goods before shipment to customers.

The "bad work" found there was "shown up" to operators and supervisors for their future guidance.

The development and application of statistical methods in textile manufacturing focused attention on preventing defectives instead of sorting them out after they had occurred.

Final inspection began to record information about the quality of goods for purposes of analysis and control in addition to the job of sorting out the bad from the good. This showed the need for controls on raw material and at process points. Inspection was extended to these areas. Quantitative measurements of quality characteristics were introduced. The theory of sampling and the use of statistical methods in the presentation and interpretation of data enabled conclusions to be drawn about material and processes and their interrelationships with known degrees of certainty and at economic cost. These techniques showed when action should be taken on the process and, equally important, when it should not. The new knowledge gained brought forth the concept that specification of the product, manufacturing, and inspection were not separate acts independent of each other, but were a dynamic cycle in which information from inspection was continuously fed back to production people for corrective and preventive action and to research and development for improvement of specifications (see Figure 1).

The Need for Quality Control as a Staff Function

The quality-control department is now a rather common staff group in American industry. Since quality is one of the most important responsibilities of line management, the need for the creation of such a staff department should be clearly set forth.

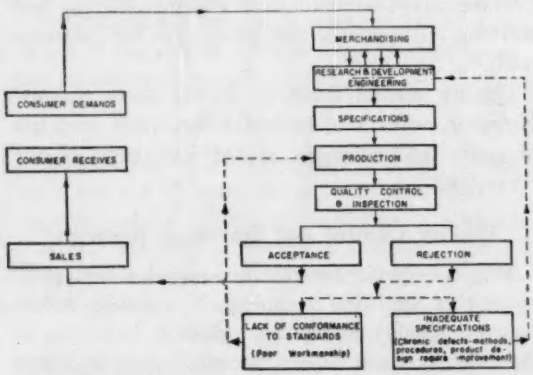


Fig. 1. The feedback principle in quality control.

As companies grow to a size employing several hundred people or more, the control of factors affecting quality falls into several hands instead of one. The production supervisors and workers are responsible for doing their job correctly. However, their performance is affected by the raw material obtained for them by the purchasing department. Purchasing, by adequately specifying what is wanted, making sure that it is obtained, and buying from suppliers who do the best job, can greatly affect performance in manufacturing. The research people who design and develop new products affect quality. If their product specifications are inadequate or methods and procedures are specified which are inherently incapable of performing well, then quality will suffer despite the best efforts of supervision and workers. The design of wage-incentive plans, the pattern of production planning, the effectiveness of maintenance, the training of personnel, and sales and claim policies all affect quality. Heretofore, particularly in large plants, each of these activities was carried on quite independently of the others. Modern quality control is the positive organization by management of these separate activities into a plant-wide quality-control program.

The Economic Basis for the Quality-Control Department

While the need for quality control as a staff function can be logically demonstrated, in the final analysis there must be an economic justification for the additional overhead created by such a department. In order to resolve this point let us begin by examining the profit picture in textile manufacturing since 1948 in comparison with all manufacturing and a few selected industries. See Table I.

The profit picture in textiles is substantially lower

TABLE I. Profits as a Per Cent of Sales *

	All Manufacturing	All Textiles	Paper	Chemicals
First 6 months 1954	3.9	0.8	5.5	5.9
1953	3.7	2.1	5.2	5.3
1952	3.8	1.8	5.0	5.4
1951	4.4	3.4	5.9	5.8
1950	6.0	5.4	7.9	8.7
1949	4.9	3.6	6.1	7.4
1948	5.9	7.6	8.2	7.1

* From *Survey of Current Business*, U. S. Department of Commerce.

TABLE II. The Average Plant

	Broad Cotton Fabrics
Value of products shipped	$5,500,000
Cost of materials (fiber)	$2,470,000 (1)
Production of yarns	4,800,000 lb
Production of waste (less that reused)	770,000 lb (2)
Value of waste	$77,000
Number of production and related workers	570
Wages production and related workers	$1,163,000

* These estimates are based on the following: (1) Census figures give cost of materials as including parts, containers, and suppliers. Cost of fiber is assumed to be 90% of this. (2) The amount of waste for broad cotton fabrics is taken as the ratio of broad cotton fabric production to total cotton manufacture times total waste. Baggings and ties are not included.

than the average of all American industry. As a matter of fact only two or three industrial groups are lower than textiles.

This poor showing is reason for far-sighted textile mill management to look with X-ray eyes at their activities, comparing them with the operations of more profitable industries and developing plans for improvement. Quality is one of the areas that must be scrutinized for profit leaks.

Obviously uniform quality of product has certain intangible values that cannot be measured in dollars, such as customer satisfaction and good will, and a sound basis for advertising. Nevertheless, since it cannot be measured accurately it will not be considered in this discussion.

An estimate of the dollar losses occurring in a cotton textile manufacturing plant because of substandard quality can be computed from the following: (*a*) discounts in the sale of seconds; (*b*) settlements of customer claims; (*c*) losses from excess material usage because of overweight yarn and fabric; (*d*) labor allowances for defective material; (*e*) rework; (*f*) waste.

In determining losses associated with quality which can be measured in dollars and cents it is surprising to see how much they amount to. A survey reported in *Factory Management and Maintenance* stated that in most companies the cost of defectives amounted to $500 to $1000 per productive worker per year. The article also stated that good quality control can cut this by 50%. An article in *Textile World* stated that, "Textile mill management is generally not aware of the huge losses being sustained due to poor quality and in some cases underestimates these losses by two-thirds. One company survey revealed actual quality loss to be in excess of $2,000,000 where management had assumed $500,000. It is conservatively estimated that the quality loss can be reduced by 50% at the end of a year."

It is possible, through textile industry statistics published in the Census of Manufactures, to develop estimates of the costs of substandard quality in the broad cotton fabric branch of the textile industry. The data included in the census consist of the total value of goods shipped in the census year (1947), total cost of materials, total wages, number of plants, number of workers, and so on. By dividing these values by the number of plants, the average plant

TABLE III. The Estimated Costs of Substandard Quality—Broad Cotton Fabric Industry

	Low-Cost Plant		High-Cost Plant	
Losses from seconds*	3% @ 25% off	$ 41,300	6% @ 25% off	$ 82,600
Losses from claims*	0.5% @ 25% off	6,900	1% @ 25% off	13,800
Losses from overweight material†	None	—	2% overweight	49,400
Labor allowances for defective material‡	None	—	1% over std. costs	11,600
Inspection costs	1% of employees	15,000	0.5% of employees	7,500
Quality-Control Department	Staff of four	15,000	None	—
Rework	Assumed	5,000	Assumed	10,000
Waste§	13.7% waste	179,000	15.7% waste	204,000
Total		262,200		378,900
Cost per productive worker		$460		$665
Difference between low-cost and high-cost plant			$116,700	

* Levels of 3% seconds for the low-cost plant and 6% for the high-cost are based on the author's observations in textile mills. The same applies to the values of 0.5% and 1.0% used for claims.

† Overweight averaging 2% or more can occur where good control does not exist, particularly as the spinner's incentive is to produce on the heavy side. Percentage overweight is multiplied times the cost of materials.

‡ Labor allowances are computed as a percentage of the wages of production and related workers.

§ Waste excludes bagging and ties. The values shown include deductions for reused waste and the value of waste. It is assumed that the low-cost mill generates 1% less waste than average, while the high-cost mill generates 1% more.

picture is obtained, and this is shown in Table II for broad cotton fabrics.

The figures given in Table II are the average for all mills producing broad cotton fabrics. In terms of performance efficiency and profits, some mills will be better than average and some poorer. By making certain assumptions one can estimate the dollar losses from substandard quality in the low-cost mill and in the high-cost mill. See Table III.

The figures show that the dollar losses arising from substandard quality per productive worker are in the range reported in the *Factory Management and Maintenance* article. However, in the cotton textile industry, waste is a large proportion of the losses. It is not susceptible to the amount of reduction obtainable in, say, the mechanical industries. Therefore, to compare the losses from quality per productive worker in the textile industry with those of others the irreducible minimum of waste ought to be subtracted. However, if one simply considers the difference in dollar losses between the low-cost and high-cost mills this does not matter.

The important point is that it is economically sound to spend money on a staff department if a good quality level is maintained. The high-cost mill has an incentive for inaugurating a sound quality-control program for the potential savings are about half the annual profit if one assumes a 3.5% profit on sales, the average of the last seven years.

The Quality-Control Program

After management has analyzed the quality situation and concluded that steps should be taken to reduce the costs of substandard quality and improve the quality of outgoing product, a program of action should be carefully developed. This generally includes the following:

1. Determine the specific operations and processes where the losses from substandard quality are concentrated. Determine the changes in product design or improvement in quality that are necessary.

2. Estimate how much of the loss can be eliminated economically.

3. Estimate the budget needed to bring about this reduction.

4. Organize the quality-control department. Outline the function of the department. Define the tools and procedures it will use. Define the department's responsibility in coordinating the quality-control program.

5. Define the responsibilities of all departments in the quality-control program.

6. Set an improvement quota for the manufacturing departments—by agreement with the line department.

7. Set up a timetable.

8. Develop a plan for communication using all the company's facilities to enlist cooperation of supervisors and employees, both line and staff.

9. Keep a record of results and review the progress of the program.

Functions of the Quality-Control Department

The quality-control department has three specific responsibilities aside from that of company-wide quality-maintenance activities. These are as follows:

1. *Testing function.* Sampling and testing raw material, processes, and product.

2. *Prevention function.* Quick analysis and feedback of testing and inspection data so that faulty manufacture can be stopped or unsatisfactory trends altered. Analyze inspection and test data to determine causes of chronic defects and recommend action. Advise and assist production in checking the accuracy of inspectors and providing statistical sampling plans and other tools for their use. Study production troubles by planned experiment. Analyze customer complaints and recommend corrective action. Participate in the development of new products to insure efficient starting production. Promote quality mindedness in all employees.

3. *Assurance function.* Make check inspections on product and prepare quality audit. Compare quality of product with competition. Make periodic reports to management on quality.

In carrying out these responsibilities the functions that follow must be organized. Some of them will fall to the quality-control department; the rest will be under the jurisdiction of other line and staff groups. The pattern will depend on the needs and organization of the particular mill. In any case, the quality-control department has a coordinating responsibility.

1. Set standards for raw materials, processes, and product.

2. Organize laboratory-control testing of the physical and chemical properties of raw materials, processes, and product.

3. Set up inspection procedures in the mill.

4. Develop statistical quality-control techniques for analysis of testing and inspection data.
5. Develop quality audit and management quality reports.
6. Organize new product-control function.
7. Develop quality-mindedness program.
8. Organize waste-control program.
9. Organize preventive-maintenance program.

The Quality-Control Department and the Organization Chart

The place of the quality-control department in the company organization will be influenced by the size of the company and whether or not it is a single plant or a number of units. It should report to an executive who reflects the company's policy on the balance between cost of quality and value of quality.

In a number of medium-sized textile mills, quality control and research and development are combined in one department. There is good reason for this since many of the tools used in measuring quality must be developed by research. Chronic quality problems encountered in daily quality-control activity often require research effort for their solution. When new processes are developed and put into production the characteristics to check and control frequently must be specified by research people. The close relationship of research and quality control is desirable; and furthermore, in a medium-sized mill it may be uneconomic to support two separate departments. In this situation the head of the research-quality-control department should report to the executive vice president or official of similar stature.

In the large plant, separation of quality control and research and development is generally a necessity since the responsibilities of both functions are great enough to require the full time of an administrator for each. Furthermore, the basic qualifications, interests, and aptitudes of a good research director are likely to be different from those of a good quality-control director and only rarely are they found combined in one person. The head of quality control in the large plant should report to the general manager or vice president of manufacturing.

Since a large part of the work of the quality-control department is to provide staff assistance to the superintendent of production in controlling raw-material quality and preventing defects in manufacturing, the question can be raised as to why the department should not report to him. The answer lies in the fact that an important responsibility of quality control is to provide top management with an unbiased picture of outgoing product quality, in effect acting as a judge of the superintendent's performance in respect to quality. Obviously a subordinate cannot sit in judgment of the individual he reports to without having some bias entering his actions.

The Manager of the Quality-Control Department

The success of the quality-control program depends on the individual heading it. One does not have to be a statistician to qualify as manager of a quality-control department. On the contrary, it has been found that in plants having successful programs the quality-control managers were characterized by managerial ability and a knowledge of the problems of production rather than scientific, engineering, or statistical competence. The ability to introduce and sell programs of change is a primary requisite of a quality-control manager. Obviously good training for such people is in the product- or process-development area. A knowledge of the elementary theory of statistics is highly desirable for the head of a quality program. Some managers lacking this have surrounded themselves with capable statistically trained people and have been very successful.

The Introduction of the Quality-Control Department into the Organization

The introduction of the quality-control department into the organization ought to be predicated on three bases: (1) that an economic need for it can be demonstrated; (2) that the measures of quality performance provided to top management by the department will stimulate the production supervisors to seek the department's help in solving their problems; (3) the department's performance can be judged in objective terms, i.e., reduction in costs arising from substandard quality. Ideally the aim is to get production supervisors to want the assistance of a quality-control department to help them do a better job. A very unsatisfactory situation is for top management to create a quality-control department without consideration of these three points. The result is that the newly formed department must constantly sell itself to production or drive for responsibilities which it should not undertake. It can result in staff domination of line, depending on

the personalities involved, rather than the staff serving the line.

When the quality-control department is introduced into the plant it should be made crystal clear to all in the line organization of production that it does not mean any reduction in their responsibility for quality. The quality-control department is to help them in executing their responsibility for quality. It does so by organizing and presenting information so that managers and supervisors can tell in a hurry what actions they should take. The name "quality control" is misleading and certainly connotes to the average plant person that it is responsible for quality. A lack of understanding on this point can be dangerous because supervisors and workers can fall into the belief that they need not be greatly concerned with quality—someone else is taking care of that.

Quality Control and Its Relation to Inspection

The organization of the quality-control department raises the question whether or not inspection activities, up to this time performed by the mill, should become a responsibility of the department. Patrol inspection in weaving and knitting, inspection of greige goods, and grading of finished product are sometimes thought to be properly a part of quality control. This thinking may stem from experience in metal-trades manufacturing where incorporation of the inspection function under quality control has been quite successful. On the other hand, in this type of manufacturing, inspection for the most part is quantitative and a well-developed science of gaging exists to support such measurement activity.

Furthermore, in these products their ability to function properly is the most important quality requirement; appearance is secondary. In textiles, for the most part, satisfactory appearance is the dominant quality requirement. Measurement of this cannot be done by gages but must be done by people. The judgment of what is seen is subjective and will be influenced by the individual's background in the organization. The representative of the weave room, the foreman in the finishing department, the quality-control man, and the salesman may see the same defects in a piece of cloth but have different conclusions as to whether it should be classified as "firsts" or "seconds." Because of the impossibility of quantitative measurement of appearance in textiles and quantitative criteria of acceptability an individual's decision on an item can be the subject of dispute. Therefore, if Quality Control is made responsible for inspection functions in the mill it opens itself to continuous argument with production as to why some goods are classified as "seconds."

Some managements have deliberately placed inspection under quality control to bring about a balance between the opposing force of production, with its desire to get the goods out even at the expense of taking a chance on quality, and quality control, with its desire to maintain standards. Obviously the balance comes from Production questioning Quality-Control decisions and maintaining pressure against any tendency of Quality Control to make uneconomic decisions.

This theory of check and balance in textile inspection has an important disadvantage in that the energies of the quality-control department are likely to be so absorbed in defending their decisions that little time is spent on the important function of defect prevention.

An approach that has been successful in a number of mills has the inspection and grading function under Production, reporting to the superintendent. The quality-control department then samples and inspects the output of the mill which has been passed by inspection as first quality. It records the quality of the goods inspected and presents the data to top management. This forms an audit of quality performed by individuals free from production pressure in making their observations and judgment. Action by top management on the quality audit provides the incentive for production to hold to or improve their standards of acceptability.

An extension of the quality audit practiced by some mills is periodically to take random samples of product from inventory, purchase similar goods of the competition, and compare them. The mill's product and competition are not identified, and the goods are judged and ranked in order of excellence of the various quality characteristics by the top-management people attending the meeting. A technique of this kind is probably most suitable for discrete items sold to the ultimate consumer, such as rugs or garments. Such an audit, practiced in a systematic fashion, can show up quality deficiencies if they exist and give some measure of comparison with competition.

Evaluating the Effectiveness of the Quality-Control Department

Good management will measure the performance of its quality-control department in terms of costs, results, and effect on profit margin.

The rapid growth and newness of the quality-control function in the textile industry has not always resulted in successful achievement in particular companies. While circumstances outside the control of the people in charge of the quality program may have been a factor in this, the chances are that the trouble arises from lack of skill in managing the quality function.

Some quality-control people tend to carry on unnecessary testing programs. It is worth while to test only quality characteristics on which corrective action or process change can be made. Adherence to quality levels which are uneconomic and have no bearing on customer acceptance is not infrequent. Knowing the quality requirements of the market and the quality levels of competition is basic information for sound administration of a quality-control program. Intense preoccupation with abstruse statistical aspects of data analysis and presentation is often found. A proper perspective is to consider statistical techniques as tools in achieving prevention of defects and not as the "be all and end all" of quality control. Numerous and unnecessary reports for management to read are likely to come from the zealous and inexperienced quality-control department. Management should be concerned only with situations that are exceptions to the normal pattern. Quality-control people complain about the difficulties in selling their programs to management. They should realize that introducing and obtaining acceptance of programs of change is an inherent part of the quality-control operation. When such symptoms as these occur careful review, analysis, and reorientation of quality-control activities are in order.

An effective quality-control department pays off. A few years ago a large textile manufacturer initiated a well-defined quality-control program. The postwar demand for goods had resulted in subordinating quality to production demands with a consequent lowering of standards. The immediate effect of the program was to increase the amount of seconds made because of tightening of quality standards and inspection. A program of defect prevention was begun. At the end of the first year the amount of seconds made was 6.5%; the second year, 5.5%; the third year, 4.6%. The current level is 3.5%. The reduction in losses from discounts for seconds alone amounted to $100,000 each year. Customer complaints were reduced by one-half. Before the installation of the quality-control program the amount of seconds made by the company was greater than the average for the industry as shown by trade-association statistics. Today the company's level of seconds is running below the average for the industry.

The result of a successful quality-control program was to improve quality, reduce costs, and improve the company's competitive position. Success of this kind will be the reward of the company whose quality-control program is keyed to the objective of preventing defects at an economic cost consistent with customer satisfaction.

Joanna Mills Quality Tests and Variation Control Methods

Joseph L. Delany

General Superintendent, Joanna Cotton Mills Company, Joanna, South Carolina

AT JOANNA a great many quality tests are made that do not differ greatly from what the average mill's standards department uses. We have found, over a long period of time, the tests, checks, control systems, and techniques that bring us more closely to the results we want. The following summary of the actual tests used will perhaps aid in understanding the methods to be described.

Baled cotton. Tested for moisture content, weight, and fineness. Samples checked on Shirley Analyzer for waste and trash as to quality and quantity.

Openers. Moisture content, Shirley, Micronaire, Fibrograph, Pressley, and tar spots.

Pickers. Moisture content, Shirley, Micronaire, Fibrograph, Pressley, weight, neps, and nonuniformity.

Cards. Nonuniformity, Shirley, Micronaire, Fibrograph, Pressley, size, and neps.

Drawing. Nonuniformity, Micronaire, Fibrograph, Pressley, and size.

Roving. Nonuniformity, size, twist per inch, and ends down.

Spinning. Nonuniformity, size, breaking strength, twist per inch, and ends down.

Spooling. Breaking strength, tailings tests, and Kidde Tensometer tests.

Warping. Yarn count and beam weight and yards. Stops per beam.

Slashing. Per cent dry starch added, moisture, and stretch.

Weaving. Stops per loom per hour.

Cloth room. Tickets made out for every roll and turned in to Standards Department, which compiles and issues weekly summary. Tar spot tests made. Construction, break, size added, neps, and moisture.

These tests are listed in order to give a clear indication that there is no short easy route to absolute uniformity of product. It is a hard uphill fight every day in the week, and it takes the full-time efforts of a good-sized staff and much high-priced scientific gear in order to maintain control.

Blending by Fineness

Blending by fiber fineness is still a very important part of quality control. In the light of present-day Micronaire readings, which seem to become higher and higher every year, it makes good sense to go all out in blending by fineness. Some few years back we had no difficulty in securing staple of almost any desired fineness. At the time our Micronaire was purchased in 1950, we were very much concerned about getting too many neps in our goods because the cotton was so fine. We had been assured that anything under 4 Micronaire was of a definitely nep-forming character. That year there was a preponderance of fine cotton and very little coarse.

We got set for a bad time. We looked for the very worst, and even took out our blade beaters at the breaker pickers, replacing them with carding beaters which had been found to be easier on the staple and less nep producing. That year was really grand. Our blend averaged 4.00 with a range from 3.20 to 5.60. The work ran beautifully; neps and waste stayed low; yarn strengths improved; and never had our spinning run so well.

This is mentioned because very infrequently do we now run into cotton under 3.75 fineness. Two years ago there just was no fine cotton to be had. Our Micronaire readings were averaging 4.60, and our work was very poor.

Our present basis for fineness blending is to separate the stock into five lots. Number 1 is 4.00 and under. Number 2 is 4.00 to 4.35. Number 3 is 4.35 to 4.65. Number 4 is 4.65 to 5.00. Number 5 is 5.00 and over. This high range forces us to run all of our 40's filling from the Number 1 and Number 2 categories. The rest goes into our somewhat heavier warp yarns. Checks made at the pickers and double-checked at the draw frames show an average for filling of 4.00 Micronaire and a warp stock average of 4.50.

My preference for a 40's filling would be around a 3.75 Micronaire and about 4.00 Micronaire for a 30's warp. At these ranges our neps could be held under control; the spinning end breakage would run low; the yarn strength would be high; and waste would be at a minimum. These are all very desirable qualities, and certainly no pains should be spared to attain them.

Joanna 4-3-2-1 Blending System

The usual practice in most cotton-opening rooms is to put down as many bales as can safely be contained in the room. This is done in order to get as large a blend as possible. In numbers there is safety, and this definitely applies here. There is, however, a catch. Most mixes are put down by the shipping crew or by the same crew that unloads the bales as received at the mill. Since this crew usually works only daytime hours, it follows that the mix must always be set down on the day shift. Picture an opening room at the start of a shift. The bales in the mix are almost depleted. What remains are mostly stubs. The stock is soft and fluffy. The operator must dash madly from one machine to another in order to keep enough fed to maintain the pickers. Here we have bulk which fills up hoppers but which, having no weight, quickly runs out and keeps the pickers frantically signaling for more. The picker tenders stop a few machines in order to keep some semblance of control, but in the meantime, lap weights have gone to pot. The same fluffy cotton that came from the bale stubs and fouled the hopper controls by its weightless volume is now repeating itself on the pickers, causing both variation and rejected laps.

Meantime the day shift gathers up the stubs, piles them against a convenient post, and proceeds with great haste to put down the new mix. Now we have cotton taken off the top of the bale, but none the less soft and fluffy. The same conditions still exist and will continue until several hours after starting time when the more compacted center of the baled stock has been reached. By this time, the opener crew and picker tenders are pretty well demoralized and laps having a high percentage of variation have been made and sent on to the card room, where no amount of processing will ever restore lost uniformity.

We wanted some sort of system that would feed a precise, uniform blend every hour of the day. We wanted it to be uniform in *weight, density, volume,* and *fineness.* This could only be done by feeding from different size bales in order to blend both *fluffy* and *compacted* stock in our hoppers. The system at which we arrived consists of a long flat roller table 6 in. high, located in front of the feeder hopper and holding four bales of cotton (Figure 1). To facilitate rolling the bale we use a flat pallet on which the bale is placed. We start off by having a ¼ full bale nearest the hopper, then a ½ full bale, next a ¾ full bale, and finally a full bale at the rear of the roller table. As the bales are fed, each is depleted by a like amount so that, when the ¼-full bale is exhausted, the other three part bales may then be easily rolled forward and a previously prepared full bale put in its place. This again restores the ¼, ²⁄₄, ¾, and ⁴⁄₄ bale ratio. Since each of our bales carries its individual fineness-indication number, it is no trouble to designate definite numbers of fineness for definite hoppers. Thus, we are assured of a continuous blending of this vital quality.

There is a very important fact to note about this 4-3-2-1 feeding system. It will work well with medium- and high-density bales. These are compacted enough to stand alone on the roller feed table. They can be easily placed and will stay in position. The exception to this is bales which are not square but which have concavities on one side where they have been "rolled" in the compress plant. One can spot this and take steps about it so it is not too great a difficulty.

Our system will not work at all with country bales of uncompressed cotton. A bale of this type

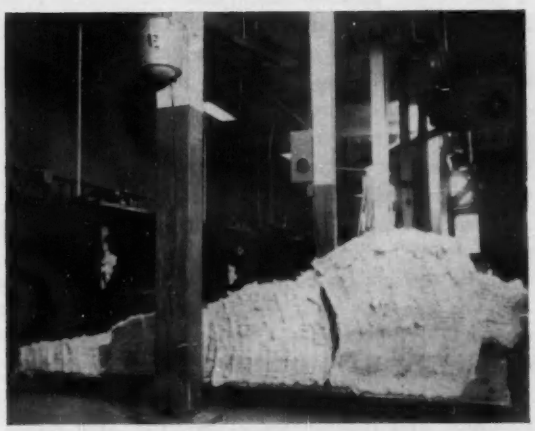


Fig. 1. Roller table.

is soft, fluffy, and very springy. When the ties are cut, the bale may immediately expand to a height of over 6 ft. Then it will fall over if not properly supported. Trying to run stock of this nature can be expensive as to cost and quality. When our industrial engineers checked our opening room, they came up with a very strange recommendation—add a man to each of three shifts. We were dumfounded, but after they had proved their point we did exactly that. Their point was that the stock, being so bulky, soon ran out of each hopper. The pickers kept calling for more that could not be fed. Actually, instead of feeding from a large-size mix of bales, we were feeding from just about one or two hoppers having a very minimum of bales. The only way this could be overcome was to put on more labor to maintain full hoppers and evenness of mix.

Since we run about 3 months each year on this type cotton, it was decided to send the bales to a compress station where they could be squeezed down to a size suitable for our use. This allows us to store more bales in less space and to save on storage area. We also save one man's labor on each shift because the more compacted stock has a high weight with less bulk. By retaining the 4-3-2-1 system, we also retain the goodwill of our insurance people, for they were by no means happy with any previous mixing-blending system.

Moisture Graph on Pickers

We have always felt some improvement should be made in checking moisture regain at the pickers. Usually there is some form of indicator hanging on a post in the picker room. This indicator is read at intervals by picker room supervision, and the reading is used as a tare allowance for moisture correction in the lap. A great many people have never been fully pleased with this device. They felt that, while it may indicate the per cent regain in the atmosphere of the room, it may not positively show the precise amount of moisture in the lap. After all, the lap is being rolled up at a rate of 50 lb in 8 min. This amounts to 6½ lb per min passing through the picker. How a hydroscopic element hanging on a post many feet away from the machine can accurately determine the regain in stock that is only exposed momentarily to the room atmosphere is a mystery to me. In the first place, the room is equipped with humidifying apparatus. This would tend to keep the regain indicator at an even level of fairly high degree. The stock is being fed into the pickers on a rapidly moving stream of air which definitely reduces the regain in the cotton. Not too many opener rooms are humidified, and it is more than likely that the cotton has dried out to some degree in storage. In short, everything done takes away moisture rather than adds it.

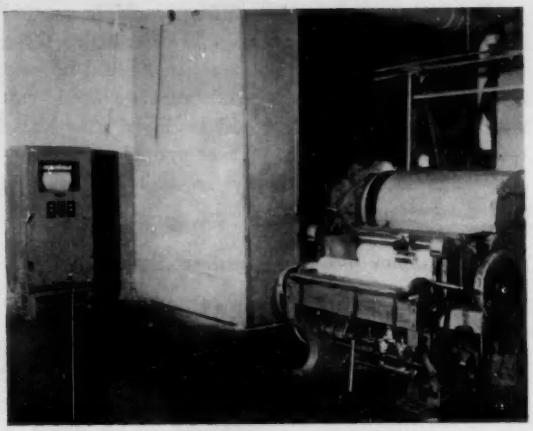


Fig. 2. Moisture-Graph unit.

The head of our Standards Department had the idea that we needed some sort of device that would measure and record the amount of moisture in the stock at the picker calender rolls. It would be done in the same manner as the regain detector roll used at the slasher. In fact, it was pointed out to us that there were on hand several surplus Moisture-Graphs. We called in the local representative and discussed the idea with him. He approved. Some slight modification of the circuit plus recalibration of the recording panel was made. We installed a unit (Figure 2) on one of our pickers with the moisture-detector roll set on the stock as it passed out of the top calendar section. The record was kept on the graphic recorder, and several times each day for several weeks spot checks were made on the moisture in the lap. This was done by taking samples to the Standards Department, where they were given a routine moisture test by bone drying. Upon comparison of results, we found the Moisture-Graph tallying almost perfectly with the actual moisture in the lap found by test. The per cent regain figure taken from the indicator hanging on the picker room post was usually several per cent higher than either of the other figures. After using the Moisture-Graph device for a considerable length of time, we have

found that moisture in the picker is usually relatively low. It ranges from a low of 4% to a high of 7%. Even with severe changes in the weather it is remarkable how uniformly low the actual regain stays.

We use but one instrument for our ten pickers and base all moisture allowances on it. It may be possible at a later date to use the graphic panel as a control device to regulate the opening room humidification system. This would not be too difficult as the manufacturer of the device built it as a control for moisture on the slasher.

Our records indicate that, after the adoption of this method of moisture allowance in our picker laps, our yarn per cent variation showed a very nice drop. It might have been several other things, but we prefer to think it attributable to the new moisture-detection system.

Effect of Card Creeling on Uniformity

One improvement in uniformity which we gained in the card room came about in a rather unusual manner. Our industrial engineers were setting up card tenders' jobs and became concerned about the manner in which the tender was continually dashing from the front of the cards to the back. He was doing this to check on the lap, to note when it would be ready for creeling, to lay piece laps, and, finally, to lay the full lap. Engineering pointed out that a good bit of wasted time was involved here and that we paid as much for walking time as we did for working time. It was suggested that, when the first lap ran out, all pieces in that creeling be immediately broken out and replaced with full laps. This, of course, was immediately met with a chorus of loud negatives. However, on mature consideration, the following was brought out. The total amount of waste added to our regular lap waste would amount to 3000 lb per 120 hr at a maximum. At a cost of 1¢ per lb this would amount to $30 per week. The gain which would occur from allowing the tender to tend his maximum potential of cards would far outweigh this small cost. We decided to try it out for several weeks, check the total waste made, and note the effect on drawing, roving, and spinning. Surprisingly enough, and to the delight of our industrial engineers, the estimate proved right as to weekly pounds of reworkable waste. Later, as the effect of this change made itself known, we found a marked improvement in coefficient of variability as well as in per cent nonuniformity ratings of our following processes. In fact, our roving per cent nonuniformity reached an all-time low of 16% on our Brush ITT Analyzer using a 1-ft sensitive length.

Control by Graphic Recording

As a general rule, it is thought good operating practice to insist that identical gears be used on all frames running the same weight product. That is, if all draw frames have the same draft plan and are all on the same grain weight sliver, then they will all have the same draft gear. Of course, there are mills using the system of sizing at different intervals —once a day, once a shift, twice each shift etc.— and changing gears whenever the weight deviates from standard. We tried this, and, while it provided some measure of variation control, we thought it involved too much changing.

We switched over to changing by the average of the daily size. That is, when the average was too heavy or too light, we changed all the draft gears on our drawing. This, too, had its faults. One week we changed all our draft gears three times. Our quality showed no improvement with all this changing or perhaps because of it. We looked pretty hard at our method, decided we didn't like it, and tried another approach.

Our new plan was to set up a graph for each four delivery head of drawing (Figure 3). On this graph upper and lower limits of control were set, and each weighing was plotted. In the course of time and with weighing every day, it does not take

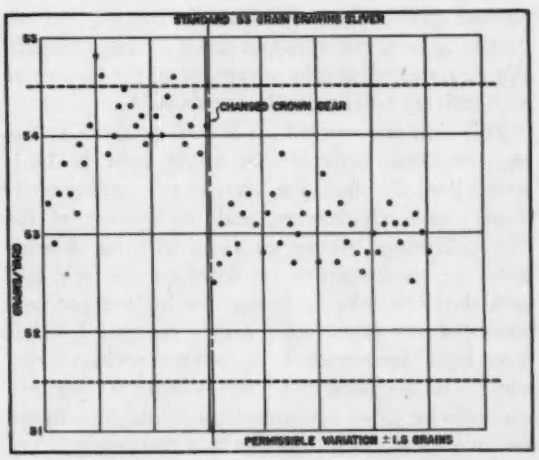


Fig. 3. Graph of four delivery heads of drawing.

long to find out whether the frame runs within or out of limits. If it is consistently out of limits, then we change a draft tooth to pull it back to standard. If it is within limits, but running consistently high or low, then we change one tooth in our crown gear. We have to keep plenty of large-size crown gears on hand, but find they really pay off.

It is, of course, quite possible to use this same method in plotting results on machines from pickers through spinning. In the course of time, it is surprising what records of this type will bring into focus.

Red Circling Out-of-Line Drawing Deliveries

A modification of the size-recording system is used by us on our drawing frames to put the finger on out-of-line deliveries. Too many times we have glanced at the average figure of a per cent nonuniformity on daily report and passed it by as all right. Then as the figure got too high, we would start to find the out-of-line deliveries. Quite often we would find that, out of four deliveries tested, only one would be high. Then we would check with the card room about this. Perhaps one had a bad roll, a wornout roll, a roll that was conical in shape, or a roll with some other deformity—a roll slide might have come loose, or a spring weight might have slipped and not be exerting full pressure. A choke in the coiler tube, a bad ball bearing in a top roll, or some other fault might affect a delivery. This made us think about how long this particular trouble had been going on. How could we ever find it before it had run too long and filled up our mill with bad work? Our method of personalized maintenance gave us some measure of control, but we wanted to keep our variation down to the minimum. We also wanted to take advantage of the history of each delivery building up in our records.

This time we worked up a card (Figure 4) for each four-head delivery that would show on horizontal lines the date, the average per cent nonuniformity on each delivery, and the average of the four deliveries. As we go along with our routine tests, the results can be set down on the form and each time the delivery having the highest per cent nonuniformity is encircled with a red pencil. If it is too high, the overseer is phoned and notified forthwith. The next time that frame is tested for per cent nonuniformity, we again encircle the highest figure and in a good many instances find that one delivery is being encircled several times. In such cases, we have the Standards Department stay with that frame until it is put in good order and passed by all concerned.

Our boss carder usually checks the high per cent nonuniformity deliveries as a matter of routine. In a good many cases he will make minor changes and then ask for a recheck to note improvement, if any. By continually checking on the highest figure, making corrections, and cutting out irregularities harmful to the work, we have succeeded in producing a fairly uniform sliver. One thing which we have very definitely minimized is wavy filling caused by a cyclic drawing-roll defect.

One Hundred Per Cent Roving Frame Testing

Lately we have begun a different type roving test which seems to be working successfully. Previously, Standards would call on the phone and report that we might be running into danger due to the roving size weighing too light. This type of advance information was always most welcome for we could immediately take steps to make whatever corrective action was indicated. Quite often when this information was not available, we could run into a bad spell of ends down in our spinning room. While we used the S. Q. C. method and it was of considerable help,

Date	Delivery				Avg.	
	A	B	C	D		
11/10/53	(22.4)	21.7	18.0	21.6	20.9	
11/23	20.0	18.7	(22.2)	20.2	20.3	
12/8	23.1	21.7	(24.0)	21.5	22.6	
1/5/54	19.6	19.9	(23.2)	19.4	20.5	
2/5	22.2	(22.7)	21.4	22.2	22.1	
3/15	(22.7)	21.6	19.0	17.0	20.1	
4/2	(25.6)	21.5	20.1	18.4	21.4	
5/26	(27.8)	23.3	20.7	22.7	23.6	
6/11	14.3	14.1	14.1	(15.9)	14.6	NEW DRAWING ROLL SYSTEM ↓
7/19	14.4	15.3	(17.5)	14.3	15.4	
8/6	18.3	14.4	(20.2)	16.8	17.4	
8/17	16.4	16.4	15.8	14.9	15.9	
9/29	(17.3)	13.9	14.1	14.8	15.0	
10/15	13.4	16.8	(17.2)	14.1	15.4	
11/29	14.6	(14.9)	12.8	13.2	13.9	

DRAWING HEAD NO. 27

Fig. 4. Card for four-head delivery.

still in this instance we felt it came up with the information too late to do us all the good possible. What we felt was needed was a daily test of every roving frame which would supply us with advance information on what sort of stock was being passed along to the spinning room. We would want to know the frequency distribution as well as deviation from standard size.

What we are now doing is to take two bobbins from each of our roving frames daily. These are identified and sent to Standards for sizing. The sizing is then graphed on two forms. One is the frequency distribution graph, which then goes to the overseer and the superintendent. This gives all a chance to note the range of sizings and the deviation from standard, as well as the average size. The second graph is the individual roving-frame size card. This graphically shows the daily average weights and whether they fall in the control area or not. The size may be within control limits, but, if it is always on the heavy side or on the light side, we can change a crown gear one tooth and pull the average closer to standard. If the size jumps all over the graph, we can check the quality of stock fed, and, if this is satisfactory, we may suspect some defect in drafting, tension, or other element of the frame.

Our roving frames are all equipped with the drop eye type stop motion, which requires a fairly tight tension in order to prevent the end from sagging and stopping the frame. For this reason, no lightweight sizings can be tolerated without seriously stretching the strand and making weak places to plague the spinner with an avalanche of end breakage.

This 100% roving-frame testing has definitely improved our roving as well as cut spinning end breakage, and we are very pleased to continue it. We feel that it keeps us ahead at all times and brings us close to the ultimate in control over very vexing operations.

Cotton Degradation

As may be noted in the description given of quality tests made at Joanna, we use the Fibrograph to check staple length at the openers, pickers, cards, and drawing. This is done for the sole purpose of catching any progressive degrading of the fiber length. If the fibers have become injured from treatment received in processing, we want to know about it as soon as possible. If any unauthorized changes in the organization have been made, we can quickly spot their effect, if any, on the staple length. If for some unforeseen reason we come up with a loss instead of a gain in our staple length, then we can be fairly certain that somewhere along the way we are injuring the fibers. This might be caused by an excessively speeded beater, too close roll settings, or an unnecessary removal of long fibers in process.

It might also be a defective lot of cotton—diseased cotton or stock which has been injured at the gin without leaving definite evidences that the cotton buyer could spot. What might appear to him to be lint of the requisite length, grade, and character might later show up poorly in process. Such fibers would produce excessive waste, high neps at the card, and *plenty of bad running work at the spinning frame.* Cotton purchases from areas having this type fiber could later be avoided, effecting very positive savings.

Management of Quality—Studies on Cotton Yarn Imperfections

Charles C. Wilson

West Point Manufacturing Company, Shawmut, Alabama

THE ART of grading yarn by use of the Seri-Plane gives emphasis to two factors of yarn quality. These factors are evenness and neps or imperfections in the yarn. Grading of yarn by this method is subject to the opinion and experience of the person doing the grading. Too much emphasis cannot be placed on the experience and judgment which are required to do a satisfactory job in this field. Also, this method does not give a quantitative measurement of these yarn qualities. The two important factors of yarn quality have been without quantitative measurement until the last few years. Electronic evenness testers have been developed that are capable of measuring yarn unevenness or short-term variation in terms of per cent nonuniformity. The industry has enthusiastically accepted these instruments. Now an electronic instrument, known as the Neptel, is available to the industry. This will count the imperfections in yarn without visual examination. The variety of factors affecting human judgment do not enter the picture when this electronic instrument is used. Consistent and reliable test results can be obtained in either the mill or laboratory with the Neptel, since it is insensitive to normal changes in ambient temperature and relative humidity.

This instrument is designed to count the number of neps, seed particles, small bits of trash, etc., existing in any sample of yarn. It ignores the usual thick and thin places in the yarn and counts only the very abrupt variations such as those just mentioned. A reliable count of the imperfections in a yarn sample is available in a very short time, as only 30 sec are required to test 50 yd of yarn. The results obtained are reproducible to a higher degree of accuracy than those obtained in visual counting. A representative sample of yarn run on the Neptel will give the same results today, tomorrow, and next week within the variability of the yarn. Also, a very close correlation has been obtained between the machine count and the average of a number of visual counts on the same sample.

Figure 1 is a picture of the instrument. It is completely self-contained, including a bobbin holder for the yarn, a tensioning device, and the necessary guides to pass the yarn through the light beam and down to a winder which is mounted in the lower part of the cabinet. Figure 2 shows a close-up of the controls and counting apparatus which are located in the upper portion of the cabinet. The operation of the unit entails the threading of the yarn through the guides as is shown in the picture, setting the A-set and the B-set knobs to the desired values, turning on the winder, and turning the reset knob to count. The light just above this knob will turn on, indicating that counting is taking place, and then off at the end of 30 sec, indicating that the counting is complete. The number of imperfections in 50 yd is then read on the electronic counter located at the right side of the instrument. If it is desired to make a number of counts on one sample of yarn, it is only necessary to turn the knob to reset and back to count to make as many readings as desired.

Principle of Operation

The yarn passes through a high-intensity, ribbon-shaped beam of light, causing variations in the amount of light that falls onto a photocell. The photocell converts these changes into electric signals which are passed through suitable electronic circuits to operate the counters whenever a nep or similar imperfection is viewed.

Generally speaking, the rate of change of diameter of an imperfection is inversely proportional to its length. A short imperfection has a very high rate of change, while a longer imperfection such as a slub has a low rate of change. This characteristic is utilized in the instrument to give a measure of the length of the imperfection. The A-set control accomplishes this. The positions of the control have arbitrarily been numbered 1, 2, and 3. We have chosen position 3 for average use, as it most nearly approximates the length of imperfection as deter-

Fig. 1. The Neptel.

mined by the human eye. Positions 1 and 2 are available for special applications as needed. The B-set control, on the other hand, adjusts circuits which determine the minimum diameter of imperfection to be counted. When the B-set control is set at a low figure such as zero, only the largest imperfections are counted. As the B-set control is advanced or increased in setting, smaller and smaller imperfections are counted along with the larger ones. No imperfections with a diameter less than that determined by the setting will be in the total count, but all imperfections of that size and larger will be counted. The values of B-set given in the correlation of data herein have been chosen for discussion because they give results essentially equal those from the average visual count. Other positions of the B-set may be used if the finished product is affected to a greater or lesser extent by the presence of these imperfections. Calibration means are provided which introduce a known change in the amount of light falling on the photocell, allowing the instrument to be checked at any time. This calibration equipment is completely self-contained and can be rechecked at any time in a very few seconds.

TABLE I

1¼-in. cotton	0.87
1 1/16-in. cotton	0.81
15/16-in. cotton	0.91

In order to evaluate the Neptel, establish test procedures, and correlate results in reference to existing information on nep counting, a series of carded yarns was made by the Research Division for test purposes. These yarns were spun in a count range of 10's to 100's in intervals of 10. Three different staple lengths of cotton were used—15/16 in., 1 1/16 in., and 1¼ in. In a deliberate attempt to make different grades of yarn, three different carding speeds were used. Each staple length was carded at 3 lb/hr, 10 lb/hr, and 20 lb/hr. The yarn made from stock carded at 3 lb/lb had the fewest neps, and the yarn made from stock carded at 20 lb/hr had the most neps. The yarn spun from the stock carded at 10 lb/hr had an intermediate degree of neppiness.

As the three cottons were being carded, nep counts were made on the webs produced at the three rates of speeds. The North Carolina State method of counting neps was used. A simple correlation analysis was made between the card neps and the Neptel test results on the various yarns. The correlation coefficients are shown in Table I.

Generally, it may be said that neps in the card web correlated with the Neptel test results on the yarn with an average coefficient of 0.86. This indi-

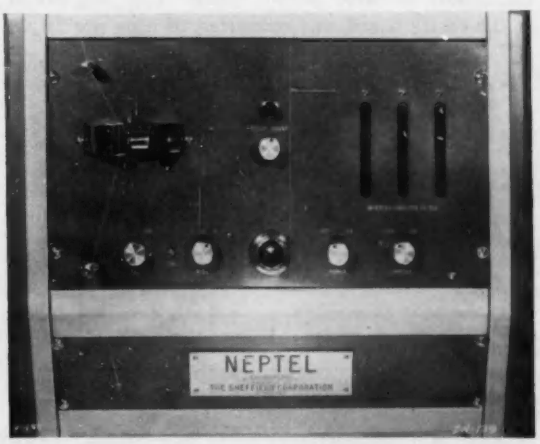


Fig. 2. Neptel controls and counting apparatus.

TABLE II

Staple Length (in.)	Yarn Number	Rates of Carding		
		3 lb/hr	10 lb/hr	20 lb/hr
15/16	10	77	104	141
15/16	20	54	84	117
1 1/16	20	65	90	113
15/16	30	53	75	113
1 1/16	30	61	90	113
1 1/16	40	63	81	94
1 1/4	40	108	242	288
1 1/16	50	59	86	106
1 1/4	50	157	310	365
1 1/4	60	187	225	312
1 1/4	80	140	321	380
1 1/4	100	80	210	206

cates good agreement between the visual count on the card web and the imperfections in the yarn as counted by the Neptel.

Each of the yarns spun was sampled at random, and a Seri-Plane board was made of each bobbin of each sample of yarn. These boards were photographed, and a visual nep count was made on each photograph. The visual nep counts on the yarns were made by three members of the Research Division staff who are highly trained in nep counting. Every effort was made to keep any bias out of the results. Each person kept his count secret until all photographs had been counted. In a further effort to eliminate bias, the photographs were coded so that the persons doing the count did not know which of the yarns was under inspection. Each visual count result is an average of the count on each bobbin of the sample, and each bobbin result is an average of the counts of three people. The visual nep count of the entire board was converted to neps per 50 yd

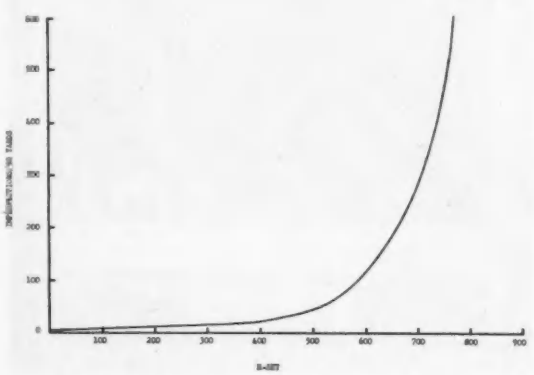


Fig. 3. 30's single yarn, 1 1/16-in. staple, carded at 3 lb/hr.

TABLE III

B-Set	3 lb/hr	10 lb/hr	20 lb/hr
0	6	11	16
100	10	14	19
200	13	19	32
300	16	27	39
400	29	37	65
500	46	63	105
600	115	124	211
700	280	318	531
800	982	906	—

to correspond to the length of yarn tested by the Neptel. The results are shown in Table II.

The test samples were run on the Neptel at every B-set from 0 to 900 in increments of 100, and an average of the sample bobbins was calculated for each B-set. The entire range of B-sets was used in order that the shape of the entire curve might be obtained. On some yarns, the count was so high at B-set 900 that the results were not included since they could not be conveniently shown on the graph. In these cases the test stopped on B-set 800. Typical test results are shown in Table III for a 30's yarn.

Graphs were drawn for each test, and a curve was fitted to the points. Figure 3 shows the curve obtained on the 30's yarn spun from 1 1/16 in. staple cotton carded at 3 lb/hr. All the yarns had the same characteristic curve, which is somewhat similar to an exponential curve and also bears some resemblance to a hyperbolic curve. Figure 4 shows the curves obtained on 30's yarn spun from 1 1/16 in. staple cotton carded at the three carding rates. The increase in imperfections is readily apparent. The curve obtained from a very good 30's combed yarn

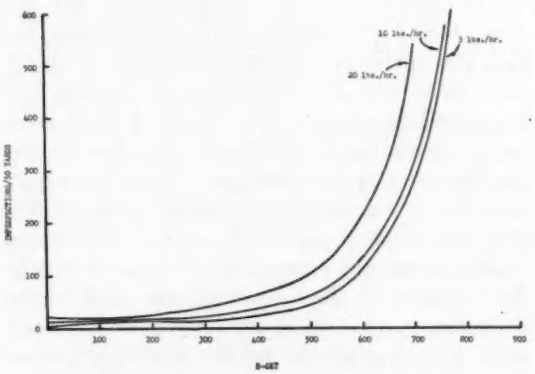


Fig. 4. 30's single yarn, 1 1/16-in. staple, carded at three speeds.

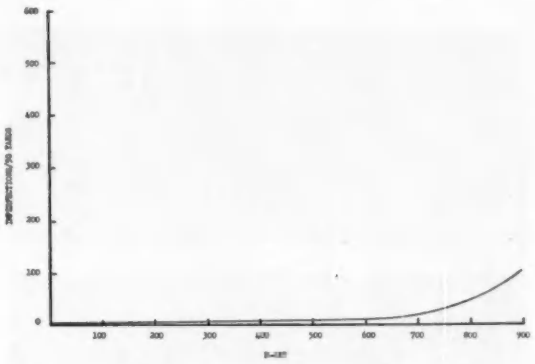


Fig. 5. Curve for 30's CP combed knitting yarns.

is shown in Figure 5. The yarn represented here is a knitting yarn. The same general curve is evident on all three charts and is typical of Neptel test results on any yarn run on all the B-sets.

While each of the yarns was run through the entire range of B-sets in order to obtain the characteristic curve, in ordinary testing this instrument will be run at a given B-set and an average for the sample reported as the number of imperfections per 50 yd. Ideally, the B-set will be the setting that will correspond most nearly to the visual nep count. Thus, results from this machine will be associated with mill practices and procedures and will be more readily understood by the production man. It would also be ideal to have one B-set for all yarns. However, test results show that this is not possible. When the Neptel data was plotted against the visual count, the graph clearly showed the necessity of more than one B-set.

In the correlation analysis, various B-sets were tried, and the results obtained were compared with the visual count. While all the B-sets correlated with the visual count, the highest correlation was obtained with the B-sets 500 and 600. The yarn numbers up to but not including 40's correlated best with B-set 500. The yarn numbers 40's and above correlated best with B-set 600. The coefficients of correlation for both B-sets are shown in Figures 6 and 7.

Almost everyone in the textile industry is familiar with the use of such tests as skein strength, single-strand strength, and nonuniformity in yarns. They realize the value of these tests in controlling the quality of the product. The Neptel can be used in much the same manner as an aid in controlling the important quality of yarn imperfections. It can be used to measure the effectiveness and merit of changes in processing procedures such as card production rates and beater speeds in the picker. The effect of the various fiber properties on yarn imperfections can also be evaluated. The ways in which this instrument can be used might be illustrated by some of the following examples.

Two samples of 36/1 combed yarn made by different processing procedures were tested. Both samples had been made from the same stock, but one sample had been processed on a particular machine one time while the other had been processed twice. Neptel results on these samples were 13 and 19, respectively, with yarn grades of A and A-.

Another interesting case concerned two samples of 26/1 carded knitting yarns spun from the same

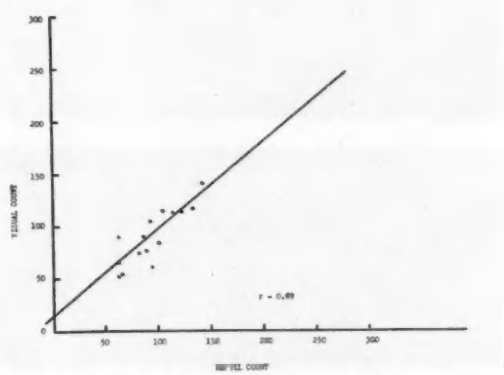


Fig. 6. Correlation of Neptel count with visual nep count. Yarn numbers under 40's. B-set, 500.

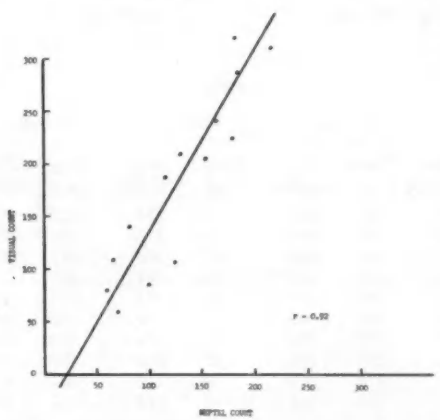


Fig. 7. Correlation of Neptel count with visual nep count. Yarn numbers 40's and above. B-set, 600.

TABLE IV

	30/1 Warp Yarn			40/1 Filling Yarn	
	Fillet	Metallic		Fillet	Metallic
1	86	76	1	103	67
2	93	81	2	92	93
3	78	66	3	92	56
4	72	69	4	73	74
5	80	79	5	84	69
6	66	60	6	92	74
Ave.	79	72	Ave.	89	72
	8.86% difference			19.10% difference	

roving, but on two different makes of spinning frames. Results of this test showed readings of 25 and 35 with corresponding grades of B and B-.

A test was made on yarns spun from stock carded on cards clothed with metallic and fillet wire. Results of this test are shown in Table IV.

A test of considerable interest was made on some yarns spun from identical stock but processed on two different pickers. One picker was set up according to the mill standards, and the other contained certain modifications for improvement of lap uniformity. Results of this test are shown in Figure 8.

In making tests on yarns that had received various treatments after spinning, it was noted that the winding process appeared to increase the number of imperfections in the yarn. This matter was further investigated to determine the cause of this increase in yarn imperfections. Table V shows the results obtained when similar yarns are wound on three different types of winders.

Worn, grooved, and rough parts of the winder over which the yarns were passed, as well as improper settings on the slub-catching plates and

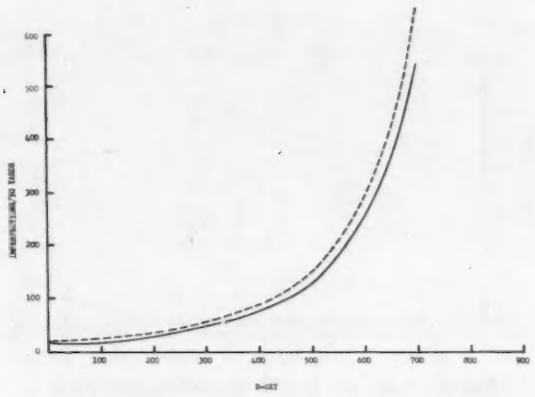


Fig. 8. 21/1 yarn spun from 1-in. Middling cotton. *Solid line,* modified picker setup. *Broken line,* regular picker setup.

guides, have considerable effect on the increase in imperfections. Even though all the parts on the winder are in excellent condition, the winding operation will still cause an increase in the number of imperfections in the yarn of the type that is measured by the Neptel. This matter has been discussed with some of the leading manufacturers of winding equipment. Some of these people have shown considerable interest and have undertaken studies to see what can be done to reduce this type of damage to the yarn.

TABLE V

	Winder 1		Winder 2		Winder 3	
Bobbin No.	Original	After Winding	Original	After Winding	Original	After Winding
1	333	349	324	358	325	364
2	237	291	249	313	401	450
3	325	382	195	244	347	516
4	408	528	250	291	319	473
5	340	439	297	393	316	410
6	247	300	245	309	277	450
7	320	358	233	256	344	497
8	207	253	147	205	307	408
9	275	317	308	416	324	426
10	244	311	194	274	249	386
Ave.	294	353	244	306	321	438
% Increase		20.07		25.41		36.45

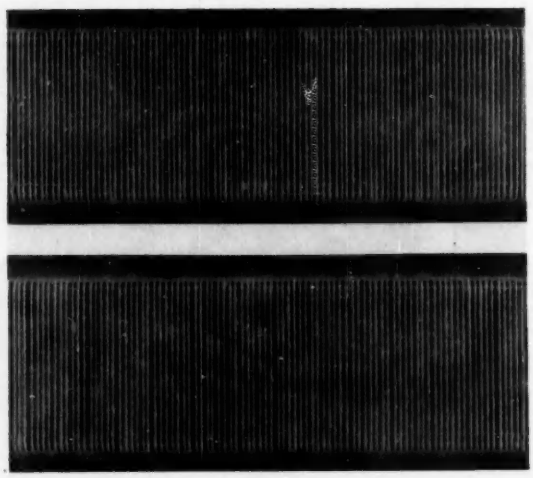


Fig. 9. Seri-Plane board of 8.00/1 filling yarn, *top* on original bobbin, *bottom* after winding.

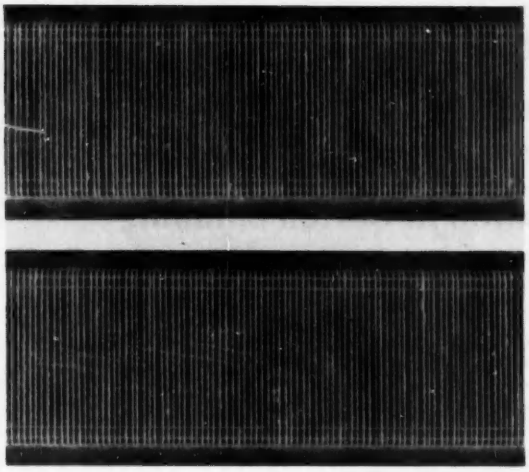


Fig. 10. Seri-Plane board of 12.00/1 filling yarn, *top* on original bobbin, *bottom* after winding.

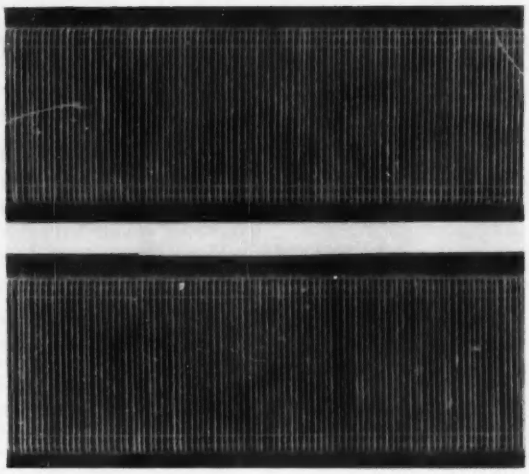


Fig. 11. Seri-Plane board of 12.50/1 warp yarn, *top* on original bobbin, *bottom* after winding.

Figures 9, 10, and 11 show Seri-Plane boards of three different yarns before and after winding. The damage to these yarns caused by the winding process is readily apparent to the eye.

Figure 12 shows the B-set curve on a yarn before and after winding. There is a great similarity between these curves and those shown in Figure 13, which was obtained from two yarns of the same count spun from the same stock which had been carded at 10 and 20 lb/hr on the card. The similarity between these two curves is readily apparent and gives us a clue as to some of the things that might be accomplished through using an instrument like the Neptel.

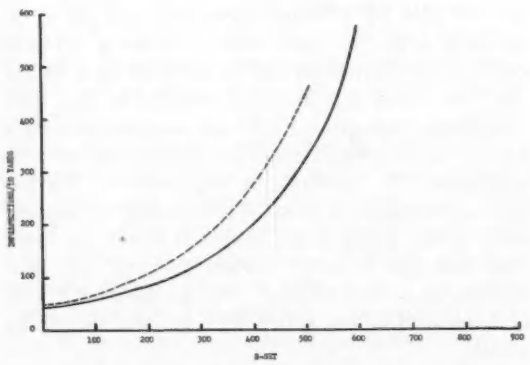


Fig. 12. 10's yarn. *Broken line,* after winding. *Solid line,* on original bobbin.

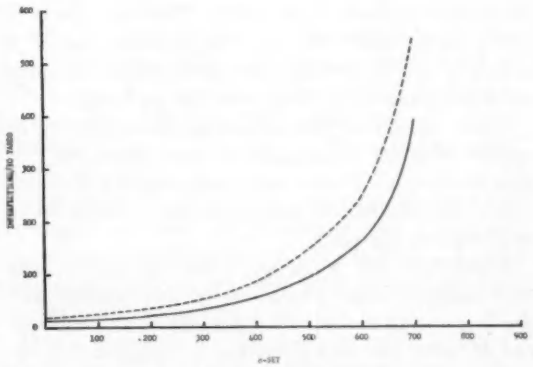


Fig. 13. 10's yarn, $^{15}/_{16}$-in. staple. *Broken line,* card rate 20 lb/hr. *Solid line,* card rate 10 lb/hr.

Management of Quality

William J. Blydenstein

N. V. Katoenspinnerij, Enschede, Netherlands

Part I: Methods of Observation in Cotton Spinning

Introductory Note

In this, the first portion of a two-part talk, Mr. Blydenstein establishes the need for more adequate methods of observation in cotton spinning. He recounts the evolution of the cotton textile mill as we know it today, cites the effects of this change on the machinery operator, points out some problems peculiar to the manufacture of textiles, and establishes the need felt by operating executives for "better visibility" of the manufacturing operation.

I shall first have to explain what I intended by my choice of subject. It is specifically *not* the increasingly popular part of quality control, which comprises the testing of cotton or of spinning results. Although this is no doubt an interesting subject by itself, I would probably not be able to tell you anything very new or different about it.

What I do wish to discuss more particularly pertains to "the tools management can create for itself to observe as directly as possible any details of the production process in the mill." This may seem to you a complicated way of saying a simple thing. I must try now to explain some fundamental thoughts on which most of the things we did are based.

When comparing the industrial manufacturing of textiles with the manufacture of other goods, we find that the textile industry was about the first industry where the small-sized production unit changed over to a regular big plant.

More than 100 years ago, when the cobbler was still making whole shoes out of raw leather and the joiner was making complete chairs and cabinets out of trees, the textile worker in England had already left behind the spinning wheel and the hand loom. Having left his home or small workshop, he was working in a textile mill in the present sense of the word. He actually was the first to become a millworker, where formerly he had been a craftsman.

But with this transition two important things happened which were to influence his performance. The first was that the worker lost sight of the end product; the second, that he lost touch with management.

I should like you to try and imagine for yourselves what this means.

Let us look first at a workshop as it may have been in the old days and as it still exists today in many trades. In any such workshop there are few problems of communication between management and labor. The boss is likely to be there himself, and he will give all personal directions and advice to his help when the need arises. When a problem pops up for the worker, all he needs to do is to ask the boss about it. In other words, he can turn straight to management. In an organization and a factory of these dimensions, the manager has no need whatsoever for "methods of observation." He has just one method. It is the oldest method of management in the world, and I believe it is still the best: "He looks for himself." When his firm is in production, he is there himself. He can see what Harry is doing, and he can watch Dick at any moment he wishes.

But now let us assume that this firm will grow and is taking on more and more help. The manager finds that he is unable to give his personal attention to all details of his production any longer, so he gets himself a foreman. The new supervisor now takes over the task of direct observation of the production process and of communication with the boss. But

the foreman has to translate his observations into an opinion on the proceedings, and, unavoidably, his boss will be dependent on the foreman's opinion. The foreman can be said to have become "a tool of observation for the manager."

It goes without saying, that, with the creation of this link between the boss (or let us call it now "top management") and the technical proceedings of manufacturing, a certain discrepancy must arise between what actually is happening at the machines and management's theoretical picture.

This discrepancy may not be too serious, and a good manager will find ways to keep himself well informed on the vital details of technical processing. Nevertheless, and unavoidably, the bigger a plant becomes, the greater is the diversity of management's responsibilities and the longer its lines of communication become.

Few subjects within the field of problems facing management today have been more discussed and written about than this matter of communication between management and labor.

While the problem of communication is one to be expected, in any type of larger plant or business, it seems to me that in the field of textile manufacturing we have to deal with a situation even more complicated than we may find in most other branches of industry.

A possible reason for this complication may be that textile manufacturing was one of the very first industries to outgrow the stage of individual production in the home or workshop of the owner-manager.

Now it may seem strange to the outsider that the textile mill, with the advantage of such an early start over other industries, should not have succeeded in finding better and more refined solutions to the problem of communication between management and labor. If there were a need for more effective methods of observation in our industry, we certainly had the time for profound development.

What, then, may be the reason for our textile industry's failure to advance beyond other industries in its system of communications and methods of observation?

There are a number of possible reasons, all of which may play a part, but the most obvious answer is this: When textile manufacturing became an industry in its present sense of the word, the expression "efficiency" possibly had not been coined. The word may have existed, but it seems doubtful that its application would have played an important part in the organization of a textile mill of those days. While other industries grew up at a time when management was already becoming a science by itself, the textile mill was largely following the pattern set in days when the issue of being competitive was restricted mainly to whether you had a machine with a greater number of spindles and whether you ran it by hand, by a mule, by water, or by steam. The effectiveness and the efficiency of labor must have played a minor part, and we are, perhaps, still suffering the aftereffects of this historical development.

When technical progress changed the craftsman into a textile worker, it changed more than his manual duties. It also changed the individual's attitude towards his work.

A drawframe operator feeds cans of card sliver to one end of his frames and takes away the full cans of finished sliver at the delivery side. This is a very useful and necessary operation to the technician who knows all about fiber processing. But is it to the operator? Undoubtedly he is told what the idea is, and he can see that there is a technical difference between the slivers he feeds into his machine and the slivers that come out. But has it truly any practical meaning for him? Has he a reason to make the appearance of slivers produced on his machine a matter of his personal pride? I am afraid he has not.

It seems more likely that his main interest will be directed toward making the necessary production to earn his maximum wage and avoiding certain mistakes for which he runs the risk of being penalized.

You will understand that there is a fundamental difference between the mistakes our drawframe tender wants to avoid and those which his ancestor, processing his raw material into an end product, would do his best not to make.

When listening to management in mills everywhere, one is likely to hear one common complaint about the difficulty of making the operators understand the necessity of sticking to the rules of given working methods and avoiding mistakes that will influence the end product. "Why should people tending our machines be so shortsighted," they will say, "that they can't see the importance of what we tell them?"

But if management will take notice of the fact that what it believes to be its personal headache is precisely the headache of everybody else running the same sort of mill, it should realize that this deficiency of labor is not an incidental matter but that there must be a deeper fundamental cause for this phenomenon.

Here, I believe, we as managers have paid too little attention to human nature. If we complain about labor's shortcomings in neglecting our rules, might it not be wise to have a good look at a large inheritance in mill organization which we accepted and which, rather strangely, seems to have escaped our criticism?

Since the days when textile manufacturing became a mill industry we have done a lot to improve our machines and the technical part of our processing. But did we really do as much about our working methods?

It is enlightening to project ourselves into the world of a mill worker tending a certain type of machine. We can imagine ourselves doing a certain type of work, not just for the moment, but day after day and year after year. Assuming that we have none of our present knowledge of management affairs and the techniques of manufacturing, we should examine our outlook toward running a machine with no more training and experience than that actually required for the performance of this one job. If we try intently to picture ourselves in the role of this textile worker, what would be our attitude toward our work and our mill?

In order to understand, in a psychological sense, what our outlook and attitude toward our work under such circumstances would be, we should project ourselves from our own world as managers and executives into a world in which we are members of an organization on which our personal influence is comparatively small and of which our knowledge is limited. Let us try and see what our reactions are when we are being managed ourselves.

All of us belong to a nation. We all take our nation's interest to heart. It is in the interest of our nation that we pay our taxes. So we naturally pay our taxes, up to the last cent that we legally can find a reason for. Or do we?

We have traffic regulations for our own good and our own personal protection. Parking must be regulated if we want to avoid costly and bothersome traffic jams. Speed must be restricted if we don't want to see the accident rate go skyrocketing.

And because we all accept the fact that the rules are set for the benefit of all of us, we never park where we shouldn't, even if we can't find a place for miles, and we never speed, even if we are in a great hurry. Or do we?

And, Mr. Executive, if your doctor tells you that it would do you some good if you would eat less, or smoke less, or drink less, you will accept and strictly follow his advice for every day and every hour to come! Or will you?

In human society a good part of our intelligence is spent on guessing what we can afford to get away with, with impunity. In fact, without wanting to consider such efforts in a derogatory sense, our whole social organization is based on doing as little as possible for a maximum of benefit. This is the essence of efficiency.

In industry we have come to accept this attitude as a must. Our whole standard of living depends upon it.

Why, then, should it surprise us if the individual worker tries to be efficient within the horizon of his own limited world. Isn't he, "doin' what comes natur'ly"? And, mind you, he didn't create for himself the borders to his limited vision. That's our work.

Accepting our worker's attitude as a result of our organization, we must now ask ourselves what we can do about it.

It seems clear that a problem of observation hardly exists for management in cases where any faults or mistakes made during the production process can be traced back to the individual operator responsible for them.

In almost any other production process but textiles it is possible to organize a quality-control system in such a way that the units are marked and each person who played a part in the processing of a unit can be identified. If such is the case, the worker automatically gets a personal interest in his performance. And deviations from his task and any faults he makes may reflect on his earnings or even on the possibility of keeping his job.

In some parts of our textile manufacturing—in weaving, for instance—we are in this lucky position too. But let us look at the carding and spinning part of our production process again.

Let us imagine ourselves once more to be drawframe operators. How much bad work can we make without anybody being able to hold us responsible for it?

Let us assume that we are working in a medium-sized or large mill, producing on three shifts and with a good many operators tending drawframes.

Do you believe it will take us very long to find all the shortcuts and simplifications in our manual duties which we can afford to take advantage of without running into practical trouble for ourselves?

For management and for our quality-control technicians, a good piecing in a drawframe sliver is one that will have no bad effect on the quality of the finished yarn.

But for us, living as drawframe operators in the isolation of our own world, the only qualification for a good piecing will be that it does not backfire on us.

Can you imagine it is interesting for a card tender to take extra trouble to make sure that he lays his laps very evenly, so there won't be too much irregularity in the sliver? What does it do to him when, by taking it easy and laying on his laps less carefully, his slivers are not quite so good?

"Sure," we can say, "he's being paid for doing it the proper way. So he has no right to take this freedom."

I won't argue that point. And I want you emphatically to understand that I am not defending labor's right to ignore our rules. My sole purpose is to clarify the practical reasons why we have a problem of inefficiency in the working methods of our labor at all.

I claim that, in spite of all our logical reasons why an operator should perform his task in a certain way, the chances that he will follow our rules in an absolute sense will ever remain low as long as those rules don't make sense for the man himself in a very direct way.

So, we should ask ourselves, does it make sense to our card tender, in his own limited world of looking after a number of cards, that he should do a thing in a difficult way when, with less exertion, his results appear to be practically the same?

I have not intended my comparisons to sound disrespectful toward management. By throwing a not-so-usual light on the work of the textile operator, I have not meant to leave the impression that this is a defense of the operator's right to break our regulations. But I do hope that by my effort to let you look at the work of the operator not with your eyes, but with the eyes of the man himself, you will better be able to follow my reasoning why we should look for means to lift the worker out of his isolation and to provide him with some incentive to become efficient for himself, for his mill, and for his industry at large.

Directing our attention to the possible methods of observation in cotton spinning, we might first ask ourselves the question, "What kind of a performance is this cotton spinning, anyhow?" Is it only a business? Is it a craft? Is it an art? Or is it a science? Since we are talking about finding a cure for something, we should at least know what kind of patient we are trying to help.

No doubt opinions will differ greatly as to what classification should be given to cotton spinning. I have come to the conclusion that something of all the specifications just mentioned is applicable to this ancient trade of ours.

It often seems to me that spinning cotton (or we might probably say, with justification, spinning fibers) is very much like sailing a boat. Who knows which of the two came first in the history of mankind? Now a typical thing about sailing a boat, as many of you may know, is that you can scientifically explain everything about the technique of sailing. So sailing a boat might well be called a "science." The amateur yachtsman can, if he wants to, learn everything there is to know about sailing from the numberless books that have been written on the subject. If he succeeds in this, he should be able to sail a boat as well as anybody else. But, as many a student yachtsman has found out to his surprise and dismay there's something lacking in the science. On the first occasion when things became complicated, he found that the old professional skipper would have a way of looking at the sky, at the wind, and at the sea—and then he would decide to act in a way which was not according to the rules of the book, but which mysteriously turned out to be exactly the right thing. Saying it in your idiom, the man who was "sailing by the seat of his pants" seemed to be indispensable after all.

In spinning, we find ourselves at the moment in a comparable situation. Not so long ago, no theoretical science to speak of had entered our trade. In the newer industries, science and research were

often responsible for the industrial development itself. Synthetics are a typical example of this. In such industries there is no real problem, either technical or psychological, of science being the helmsman directing its course. This all comes naturally to them. They've never known anything else. But in the old industry of textile manufacturing there seem to be two people on the bridge now, the schooled engineer and the old skipper, and the problem is who is going to be at the helm from now on.

For anybody who is aware of the rocketlike scientific development of our days, there can be little doubt about the answer. Science will have to take over, perhaps pretty fast. But in accepting this fact we have entered into a problem which, I fear, too few people are sufficiently aware of.

We see this problem in different degrees wherever science has to be the advisor of industry, without being fully integrated and part of that industry itself.

No man with a scientific training will be able to understand fully the psychological difficulties he has to cope with in introducing his ideas, regardless of their soundness or practicality. Too often his failure is not due to the fact that his supposition was wrong, but due to his ignorance about the many obstacles and pitfalls he would find on his way.

If only we could create the combination of a man, half scientific engineer and half skipper, we would have the ideal helmsman to steer our industry clear into the scientific waters. But it takes many years to become a well-schooled engineer and almost a lifetime to become a good skipper, so we shall have to do the best we can trying to use both and still keep on the right course.

In trying to get ideas across from the engineer to the people in charge of the processing, and vice versa, I found that one of the main things we lacked was "visibility of the organization."

Without many people realizing it, nearly everything in our textile mills happens anonymously. A stranger walking through a mill would not be able to understand anything regarding the production process from visible information in the mill itself. Why should this be so?

When thinking about this, it occurred to me that the necessity to advertise any plain facts regarding the processing must never have been felt by management. The worker was told what to do and what not to do.

Why should he be given any information about matters beyond his direct and personal responsibility?

I do not know how things have been here in the past in this respect, but in our industry in the old days, almost anything happening in a textile mill was considered top secret.

Most of us now have become used to the fact that progress is so fast that we can no longer afford to sit back and shut ourselves off from the rest of the world. But there have been times when technical progress went at a very slow pace indeed, and a production process would be guarded for generations with all possible means to prevent competition from entering a market. Those actually were the days when the craftsman's job had not been split into a great number of separate manipulations, and the skill needed to learn a trade might take a good part of a lifetime. The skill of its labor was the main capital asset of an industry, not the equipment, as it is now. History reveals the fact that the famous town of Venice, in Italy, would poison its skilled glassblowers when they tried to emigrate.

Few people are likely to deny that things have changed. Apart from a mill's policy of supplying no visible production details in the mill for competetive reasons, a more practical argument exists. Management does not see a great advantage in showing details to everybody who cares to look, because this might invite people to concern themselves with matters not belonging to their own duties and thus bring up unnecessary questions or complaints. And as far as my experience goes, this is actually the situation we will find in any of our textile mills today. The greater part of the information there is will be hidden in little pocketbooks and in the desks of the supervision and the mill staff.

Assuming that management doesn't think it worth the price to supply visible information, it will have to answer the question of what it expects from its labor.

Does management want to draw the interest of the people working in the mill to what is actually going on and by doing so tempt the operators to develop themselves beyond their manual tasks as much as possible? Or does it prefer to keep everybody as much in his own place as possible?

On this question every management will have to decide for itself. From our experience and working under our possibly typical circumstances, we came to the conclusion that, in order to get people to work efficiently for the mill, instead of only for themselves and possibly at the cost of the mill, we had to make things concerning their work and concerning the inside organization of the mill visible for them.

Part II

Introductory Note

The second portion of Mr. Blydenstein's paper was composed of colored slides illustrating processes in his mill at Enschede, Holland. These pictures show devices which provide "better visibility" of the manufacturing operation in the mill. Typical illustrations chosen from this group, with brief explanatory notes, are printed below.

The speeds of essential parts are recorded on plaques attached to all opening and cleaning machines. Since many speeds are varied according to the mix of cotton being processed, a constant, visible check on processing conditions is provided and operators are shown the actual treatment given to various blends.

Each machine in the mill is equipped with a holder containing a small book (see arrow; Figure 1). All mechanical changes, replacement of parts, variations in settings, etc. must be recorded in this journal. The book is designed in such a way that all routine notations can be made with a minimum of writing.

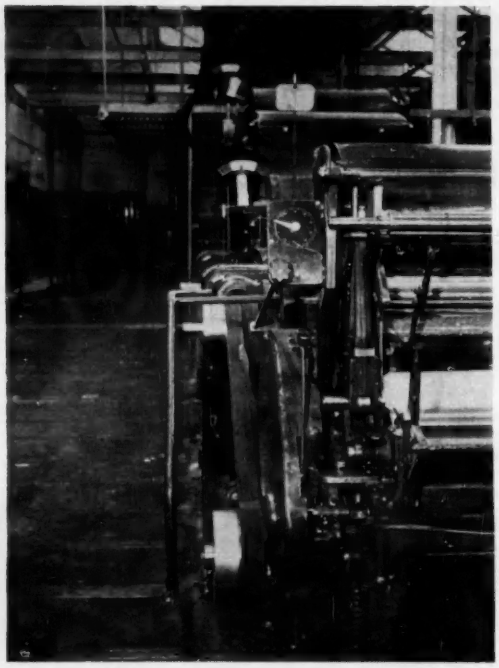
Figures 2 and 3 illustrate methods of providing better process visibility to the picker tender while he is in his normal working position.

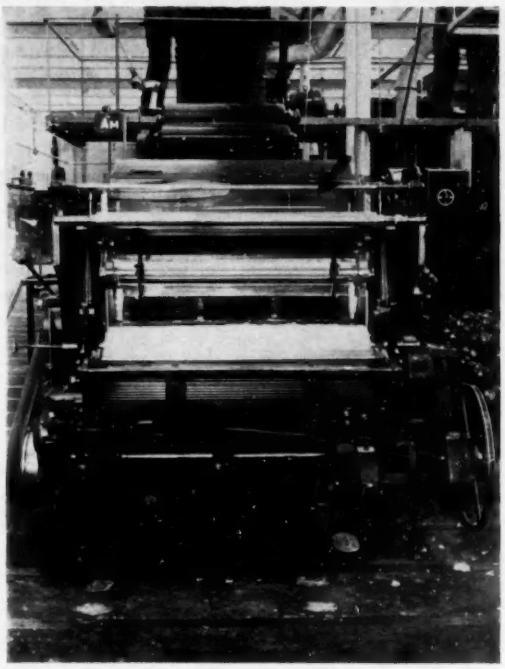
The arrows in Figure 2 indicate pointers which may be viewed from the delivery end of the picker. These pointers provide the operator with a constant check on the position of the evener belts at both the first and second regulators.

The full front view of the picker shown in Figure 3 illustrates windows which have been installed on the front side of the screen housing. A fluorescent light behind the screen enables the operator to determine, from his working position, whether screens are clear and the evenness with which the cotton is distributed over the full width of the screen.

Each of the automatic printing lap scales, shown in Figures 4 and 5, serves two pickers. The scale prints a continuous graph for the laps produced on each machine. One picket is recorded in red; the other, in black. Control limit lines printed directly on the graph show immediately whether a lap is outside of normal tolerance.

Fig. 1. Vertical opener.





Figs. 2 & 3. Picker front.

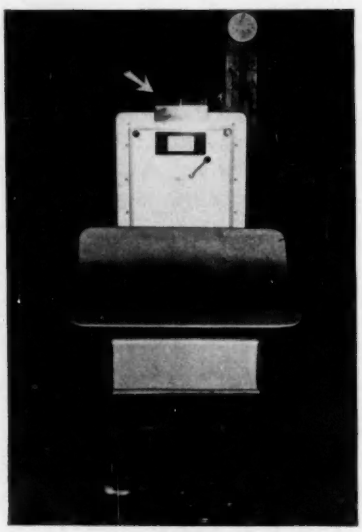


Fig. 4. Automatic lap scale.

A screen covers the window and printing area during the time a lap is actually being weighed. This reduces any tendency on the part of the operator to influence the lap weights. When the lap has been removed, the door to this window may be

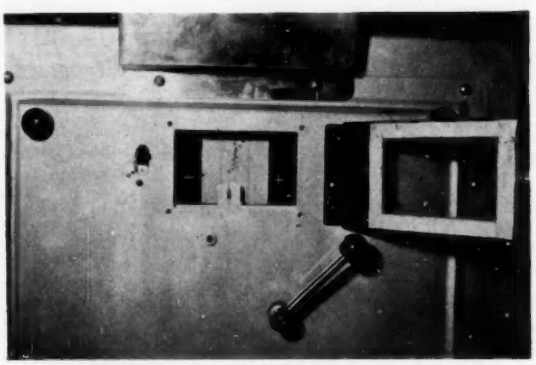


Fig. 5. Closeup of automatic lap scale.

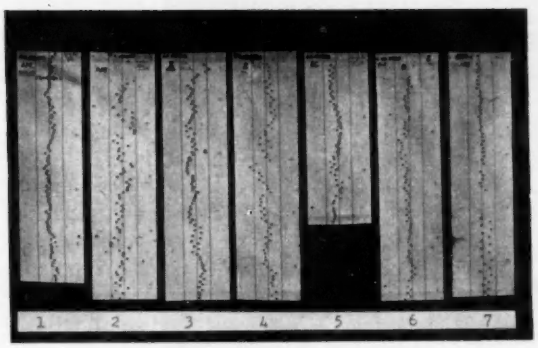


Fig. 6. Graphs of lap weights.

opened, as shown in Figure 5, and notations of the reason for off-standard laps are made directly on the chart. Routine notations are made with rubber stamps affixed to the top of the scale (see arrow, Figure 4).

Graphs 1 and 6, shown in Figure 6, illustrate the type of graph which may be expected when both of the pickers served by a recording lap scale are functioning properly. Each of these graphs represents a run of approximately 5 hr in which nearly all of the laps are well within the acceptable tolerance of $\pm$ 1/4 lb.

In graphs 3, 4, and 5 a cyclic variation may be noted. While each set of two pickers is served by one opening line, pickers are equipped with reserve boxes which have the effect of permitting each picker to operate as an individual unit. The only factor which would appear to induce the cycles shown on the graphs is a variation in the specific weight of the material fed by the opening line to the two pickers. Thus, the performance of a picker appears to be a compromise between two elements: the machine's ability to regulate the evenness of its own output and variation in specific weight of the material being fed.

Graph 2 displays a random pattern which indicates that the pickers themselves are out of adjustment, since the machines, properly adjusted, are capable of duplicating the graph shown in chart 1.

Graph 7 reveals an instance where the operator, after a period of an excellent run, neglected to keep his machines together near the center line and was satisfied that weights from one picker remained within the control limits, although repeatedly on the heavy side.

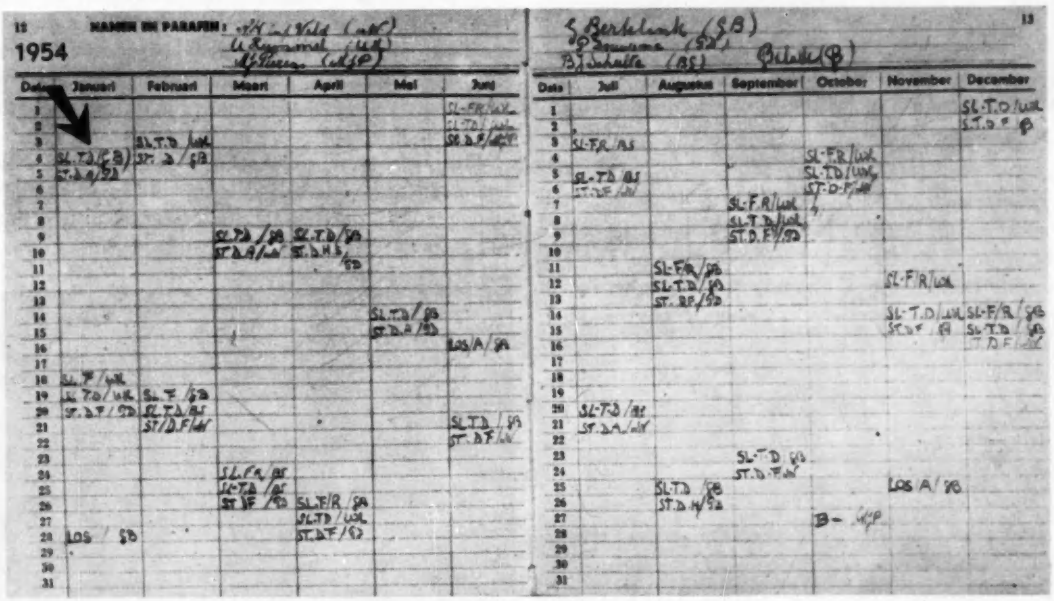


Fig. 7. Calendar page from machine book.

Fig. 8. Roving frame machine board.

Pages such as the one illustrated in Figure 7 are typical for all machine books. A double page covers one year, with the dates listed vertically and the months horizontally. Calendar pages show everything of consequence which is done to any machine. The notation "SL.T.D.(G.B.)," listed for January 4, indicates that the card has been ground. "T" stands for cylinder, "D" for doffer, and "G.B." are the grinder's initials. Items which do not fall under routine maintenance and which cannot be described by code letters are entered under specific headings on other pages of the machine book.

The board illustrated in Figure 8 is mounted on each roving frame for the purpose of furnishing complete, visible data on the product being processed and the operator tending the machine.

The top row of cards identifies regular machine operators for each of the three shifts. Each card contains two colored spots which are numbered to indicate the operator's quality-control number and the color identification code which is placed on each bobbin produced. The red tab affixed to the center card indicates that this operator is not yet fully skilled.

The partition at the lower left contains the printed identification labels which are filled in and placed in each doff of roving removed from the machine.

The center bottom partition contains a supply of red cards and three red clothespins. When any portion of the machine is in need of mechanical adjustment or repair, a red clothespin is affixed on or near this part. A repair card is filled out (most common repairs can simply be checked off) and is placed in the upper left-hand portion of the board, as shown. The card may not be removed and the clothespin replaced in its holder until the fixer has made the necessary mechanical correction.

The framed portion of the machine board at the top right lists the duties of each machine operator.

In order that the details of each machine operator's job may be clearly visible at all times, boards such as the one illustrated in Figure 9 are posted near each operation. All items pertaining to the cleaning schedule for each machine are printed on separate cards. These cards are then inserted at the appropriate place in the time-table column for each day of the week. Any change or variation in the cleaning routine may be posted by moving or replacing the appropriate cards.

The right-hand portion of the job-specification board contains detailed write-ups of the various job elements which are subject to change less often than the cleaning schedules.

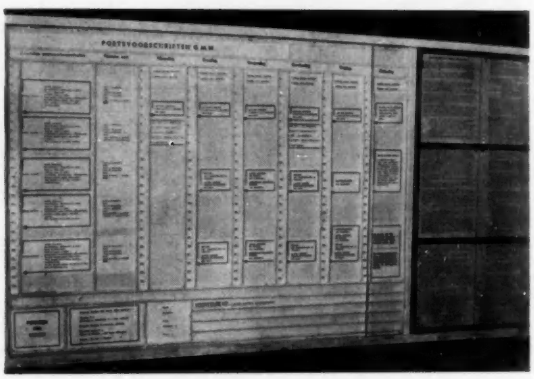


Fig. 9. Job duty specification board.

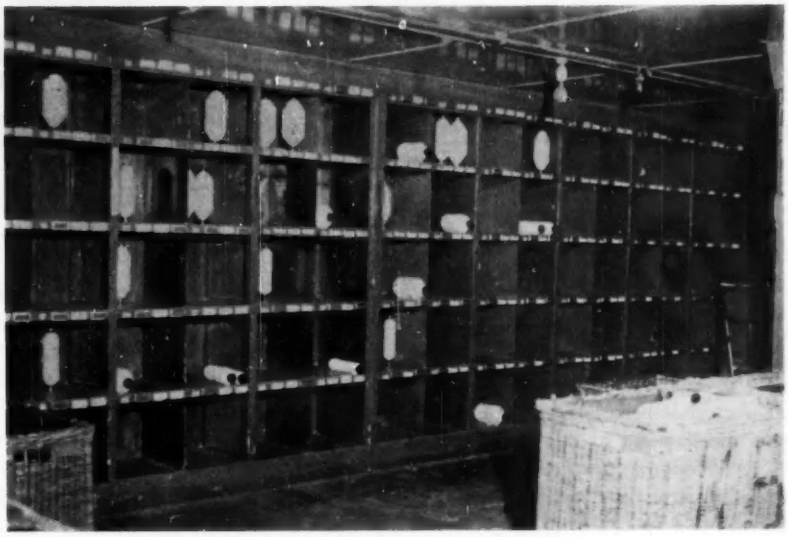


Fig. 10. Roving inspection station.

Each roving bobbin is marked with the color code of the operator who made it, and faulty bobbins are returned from the spinning room to a central roving inspection station. Here, an instructor inspects the bobbin and places it in a bin bearing the name of the operator who produced the bad work (Figure 10).

All roving-frame operators are paid on the basis of hanks produced, but an additional premium is paid provided no bad work is returned. Certain deductions from this premium are made for faulty bobbins. No money deducted in this way returns to the mill, however. All deductions are placed in a pool and are prorated among the operators with the best quality and production records.

The operator shown in Figure 11 is known as a pilot spinner. These specially trained employees work under the supervision of the Time Study Department and serve as machine operators while making ends-down checks.

The harness which the pilot spinner wears is equipped with counters on which he may tally ends-down due to nine assignable causes. At the end of the check, the vest is turned in to the Time Study Department, where data recorded on the counters is processed as an ends-down study.

The display pictured in Figure 12 is located at the entrance of the mill and contains samples of defective quality. These samples and the notations which accompany them illustrate the ways in which various types of bad workmanship are produced. The display serves as a training aid and as a constant reminder of the necessity for careful workmanship.

Fig. 11. Pilot spinner

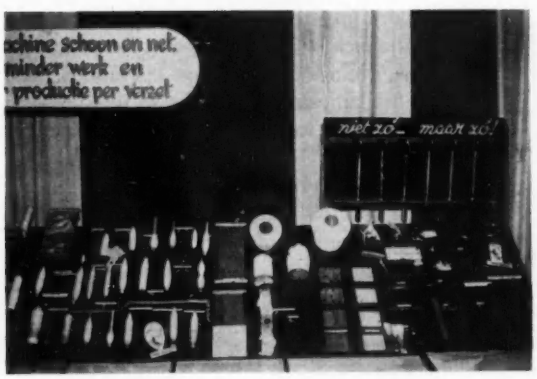


Fig. 12. Exhibit of bad work.

Effect of Colloidal Silica Treatments on Cotton Processing Characteristics and Yarn Quality[1]

Hugh M. Brown, J. H. Langston, and W. T. Rainey, Jr.

School of Textiles, Clemson Agricultural College, Clemson, South Carolina

Introduction

The application of certain chemical compounds, identified technically as a fine colloidal dispersion of silica or quartz, to cotton to increase the interfiber friction of cotton fibers has been a subject of recent interest. It has been reported that this type of compound increases the frictional properties of cotton fibers [8]. Additional investigations [1, 3, 7, 10] indicate that generally the treated cottons produced yarns of higher strength and that the twist required to develop maximum strength in treated yarns is less than that required for untreated yarns. It has also been reported [4] that colloidal silica has been successfully used on a commercial scale in the manufacture of combed yarns. Studies on wool [2, 11], where colloidal silica compounds were applied, indicated that the increased interfiber friction permitted the spinning of high-strength woolen and worsted yarns, together with a reduction in waste, ends down, and mending costs.

Though the findings to date on the effects of colloidal-silica-treated cotton on the physical properties of end products and processing efficiency have been encouraging, the application of these compounds to cotton has not been generally accepted. This lack of interest may be due mainly to (1) the unorthodox method of applying the colloidal dispersion of silica (impregnating card and drawing sliver); (2) the difficulty of drafting treated fibers, causing uneven yarns; (3) the lack of knowledge of effects of treatments on the dyeing and finishing operations; and (4) lack of fundamental knowledge in this field.

A systematic study was therefore undertaken under contract with the U. S. Department of Agriculture.[1] This study was concerned with the application and evaluation of selected additive chemical treatments of various concentrations on (1) frictional properties of cotton fibers; (2) forces required to draft the fibers; (3) sliver, roving, and yarn properties; and (4) the efficiency of dyeing and finishing processes and how these and other processes affect the permanence of treatments.

This is a report of the effect on cotton processing efficiency and yarn properties produced by use of additives such as colloidal silica and other compounds to increase the interfiber friction of cotton fibers. The dyeing and finishing phase of this investigation is to be reported upon at a later date.

Evaluation of Compounds

Based on a comprehensive literature survey on the general subject of fiber friction [5], preliminary investigations were made using approximately 100 different compounds on a Deltapine cotton. The cotton was treated with the various compounds as a step in measuring the fiber interfrictional forces developed. After the cotton was treated with the compound and carefully blended, the force required to slip two tufts of paralleled fibers over each other was measured by means of a chemical balance. This followed the principle used by Morrow [6] and by Schmidhauser and Stoll [9], whereby a tuft was mounted in a special holder which rested on the base of the balance. The other tuft was formed by wrapping tape around one end of a flat bundle of fibers. This tuft was pressed against the first tuft by means of a spring to give the same pressure for all tests. To measure the force, the second tuft was attached to one arm of the balance and weights were added to the opposite pan to produce slip. From ten to fifteen readings were taken on each sample. The results from these tests, shown in Table I, based on per cent solution, per cent takeup considerations are reported in terms of a friction value. This value is a relative index and can be compared to the value (35) obtained from the untreated control with the higher value indicating a higher interfiber frictional characteristic.

[1] A report of work done under contract with the U. S. Department of Agriculture and authorized by the Research and Marketing Act of 1946. The contract is being supervised by the Southern Utilization Research Branch of the Agricultural Research Service.

TABLE I. Effect of Various Agents on Frictional Properties of Cotton

Agent	Per Cent Solution	Special Treatment Conditions	Per Cent Takeup	Friction Value
None	—	—	—	35
		Colloidal Silica		
Syton	15.0	None	31.9	90
Syton	5.0	None	17.8	72
Syton	2.0	None	0.5	66
Syton	1.0	None	2.0	67
Syton	0.5	None	0.2	60
Syton	0.5	(Based on wt. of cotton)	—	50
Ludox	10.0	None	7.5	80
Ludox	7.5	None	4.1	74
Ludox	5.0	None	3.9	79
Ludox	2.0	None	0.2	69
Ludox	0.5	None	—	48
		Other Silicon Compounds		
Sodium silicate	5.0	None	5.6	43
Sodium silicate	5.0	Dried, treated with dil. HCl, rinsed with H_2O, and dried	—	46
Sodium silicate	2.0	None	1.7	43
Sodium silicate	2.0	At *p*H 8	1.9	43
Sodium silicate	1.0	None	0.7	40
Silicon tetrachloride	—	Treated in vapor phase, rinsed with aq. NH_3	0.6	59
Silicon tetrachloride	—	Treated in vapor phase 10 min, washed with water	4.0	65
Silicon tetrachloride	2.0	Treated in CCl_4 soln., then exposed to NH_3 vapor	10.5	73
Silicon tetrachloride	2.0	Treated in CCl_4 soln., soaked in 1% *tert*-butyl alcohol in CCl_4, exposed to NH_3 vapor	9.0	73
Methyl trichlorosilane	—	Treated in vapor phase 1 hr	4.0	63
Methyl trichlorosilane	—	Treated in vapor phase, washed in cold water	Tendered	
Methyl trichlorosilane	—	Treated in vapor phase 1 hr, in NH_3 1 hr	12.5	63
Methyl trichlorosilane	—	Bone-dry cotton in CH_3SiCl_3 vapor 1 hr, NH_3 1 hr	5.4	71
Methyl trichlorosilane	—	NH_3 vapor, CH_3SiCl_3 vapor, NH_3 vapor again	Tendered	
Methyl trichlorosilane	—	H_2O vapor, CH_3SiCl_3 vapor, NH_3 vapor	13.6	70
Methyl trichlorosilane	—	H_2O vapor, CH_3SiCl_3 vapor, blown with air (tendered)	9.0	73
Methyl trichlorosilane	2	Treated in CCl_4 soln., then NH_3 vapor	13.0	81
Dimethyl dichlorosilane	—	Treated in vapor phase 1 hr	6.1	37
Dimethyl dichlorosilane		Treated in vapor 1 hr, NH_3 1 hr	24.8	40
Ethyl silicate	5	In 4:1 ethanol-water soln., dried	0.3	37
Ethyl silicate	5	Same, treated with NH_4OH added to bath	1.1	37
Ethyl silicate	5	In 4:1 ethanol-water soln., then NH_3 vapor, dried	3.0	65
Ethyl silicate	2.5	In 4:1 ethanol-water soln., then dil. NH_4OH, dried	—	44
		Abrasives		
Kaolin	2.0	Aq. susp.	6.3	42
Pumice	2.0	Aq. susp.	13.9	42
Pumice	2.0	Suspended in 1% aq. glue	10.4	39
Bentonite	2.0	Aq. susp.	1.0	38
Talc	2.0	Aq. susp. + wetting agent	3.5	39
Titanium oxide	15.0	Aq. susp. + wetting agent	18.5	72
Titanium oxide	7.5	Aq. susp. + wetting agent	3.8	68
		Resins		
Stymer	1.0	Aq. soln.	—	44
Resloom M-75	2.0	Aq. soln.	3.5	43
Merlon S	2.0	Aq. soln.	2.0	45
Rhoplex E R	5.0	Aq. soln.	1.0	41
Rhoplex E R	2.5	Aq. soln.	—	41
Methacrol	15.0	Aq. soln.	5.1	47
Methacrol	2.0	Aq. soln.	—	41
Orthacryl	2.0	Aq. soln.	—	41
Orthacryl	4.0	Aq. soln.	0.9	39
Ethyl cellulose	2.0	Aq. soln.	2.0	47
Sodium CMC	2.0	Aq. soln.	—	44
Permolite	2.0	Aq. soln.	—	43
Type 8 Nylon Dv-55	2.5	70:30 ethanol-water soln.	8.4	45
Type 8 Nylon Dv-55	1.0	70:30 ethanol-water soln.	3.2	36
Type 8 Nylon Dv-55	1.0	+ maleic acid catalyst (*p*H 4)	4.5	39
		Metallic Salts		
Barium chloride	37.5	Aq. soln.	45.0	44
Barium chloride	19.0	Aq. soln.	17.5	43
Magnesium carbonate	2.0	Aq. susp.	11.5	65
Calcium carbonate	2.0	Treated aq. Na_2CO_3, then aq. $Ca(NO_3)_2$	3.7	47
Calcium carbonate	2.0	Aq. $Ca(NO_3)_2$, dried, aq. Na_2CO_3	2.9	48
Calcium carbonate	5.0	Aq. Na_2CO_3, then aq. $Ca(NO_3)_2$	11.8	47
Ammonium chloride	—	Exposed to vapors of NH_3, HCl, NH_3, HCl, NH_3	0.4	39

TABLE I (Continued)

Agent	Per Cent Solution	Special Treatment Conditions	Per Cent Takeup	Friction Value
Basic lead acetate	2.0	Aq. soln.	2.2	38
Basic aluminum acetate	2.0	Aq. soln.	11.2	45
Aluminum acetate	2.0	Aq. lead acetate + aluminum sulfate	1.6	42
Aluminum sulfate	2.0	Aq. soln. (*p*H 3)	0.8	48
Aluminum sulfate	2.0	Aq. soln. (*p*H 7–8)	2.1	72
Aluminum sulfate	1.0	Aq. soln. 2% aq. glue	2.3	78
Aluminum sulfate	0.1	Aq. soln. (*p*H 7–8)	0.9	68
Aluminum sulfate	2.0	Aq. soln. (*p*H 3), then in NH_4OH	4.0	49
Aluminum sulfate	2.0	Aq. soln. (*p*H 3), then in 2% aq. glue	1.7	51
Aluminum phosphate	0.7	Aq. aluminum sulfate + sodium phosphate	2.8	73
Aluminum phosphate	0.3	Aq. aluminum sulfate + sodium phosphate	0.9	75
Aluminum phosphate	0.1	Aq. aluminum sulfate + sodium phosphate	—	56
Aluminum phosphate oxalate	0.7	Oxalic acid added	0.7	44
Aluminum soap	1.0	Aq. soap, then aq. aluminum sulfate	—	42
Titanium chloroacetate	2.0	Titanium sulfate in HCl + lead acetate, neutralized	0.2	49
Titanium chloroacetate	2.0	Same as above, then in aq. 5% NaOH + sodium silicate	—	45
Titanium potassium oxalate	2.0	Aq. soln.	0.7	43
Zirconium oxychloride	2.0	Aq. soln. (*p*H 3)	3.9	51
Rosin soap	2.0	Aq. soln.	—	38
Sodium	18.0	Aq. soln.	33.1	68
potassium ethyl phosphate (Sopet)	10.0	Aq. soln.	13.6	65
Sodium potassium amyl phosphate (Noshock A)	1.2	Aq. soln.	1.0	46
	10.0	Aq. soln.	9.0	56
Miscellaneous Agents				
Gelatin	2.0	Aq. soln.	—	39
Gelatin	2.0	Aftertreated in 45% aq. lead acetate	0.0	42
Gelatin	2.0	Aftertreated in 10% aq. formaldehyde	—	45
Keltex	0.13	Aq. soln.	—	43
Starch	2.0	Aq. soln.	2.8	50
Starch	2.0	Aftertreated in 5% aq. formaldehyde	—	47
Tween 20	2.0	Aq. soln.	1.0	45
Diapene-NS	2.0	Aq. soln.	0.03	56
Nonslip 411	2.0	Aq. soln.	0.00	49

In general, use of compounds of silica and titanium dioxide resulted in the greatest increases in frictional force evaluated in terms of the friction index.

Using information from this preliminary study as a basis, six different cottons having a wide range of physical properties, shown in Table II and identified as *B, C, D, E, F,* and *H,* were treated with two compounds of colloidal silica and two of titanium dioxide. The treatment was sprayed on portions of the picker laps held between wire nettings. The treatment was made uniform by a constant-pressure "microsprayer." For every piece of lap treated an adjacent similar piece was used untreated as a control, the two being kept together through all steps of processing and testing. To find the optimum amount of additives to use, many dilutions of each compound were applied to samples from each of the six cottons. All samples with their controls were carded into 50-grain slivers which were given double drawing. The drafting force was measured for each treated sample and its corresponding control.

TABLE II. Fiber-Property Summary

Number	Variety	Strength, Pressley Index (lb/mg)	U.H.M.L. (in.)	Fineness (μg/in.)	Maturity (%)
B	Coker 100	7.7	1.06	4.3	90
C	Iquitos	6.9	1.06	8.0	96
D	Bobshaw	8.3	1.02	4.9	90
E	Unknown	7.5	0.88	5.2	80
F	Unknown	7.2	0.90	4.0	55
H	Wilds	8.0	1.30	3.9	92

To measure the drafting force a special drafting-force meter was developed, the principles of which are shown in Figure 1. In this device the cotton is given a low draft by means of two pairs of rolls, one pair being mounted stationary and the other pair being mounted on an arm that is free to swing except for being held by means of a cantilever bar on which is mounted a strain gage. In such a device it is important that the driving force will not contribute torque to parts that would tend to move the arm and also that the application of the driving

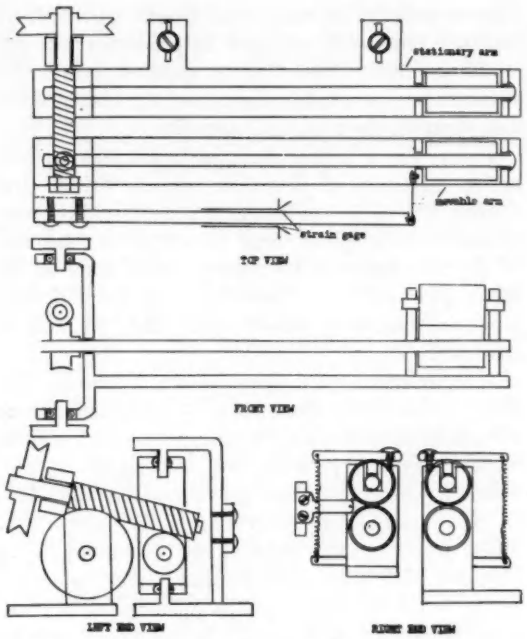


Fig. 1. Schematic diagram of drafting-force meter.

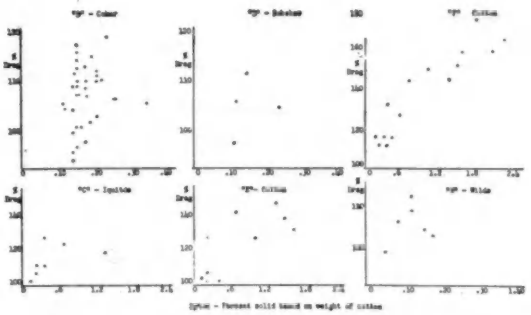


Fig. 2. Gain in drafting force of Syton-treated vs. untreated cottons as affected by per cent solids added.

force be applied very uniformly. It was found that neither a regular gear nor a belt drive satisfied these two conditions since they introduced spurious variations indistinguishable from true variations of the drafting force. A worm-gear drive which eliminated these variations was mounted on both pairs of rolls and the movable arm mounted by means of a yoke having ball-bearing pivots above and below and centered vertically with respect to the point of contact between the driving worm and the worm gear for this roll. Thus, the force at the gear can contribute no

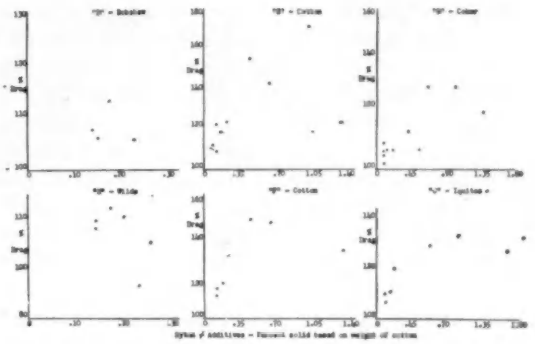


Fig. 3. Gain in drafting force of cotton treated with Syton plus additives vs. untreated cottons as affected by per cent solids added.

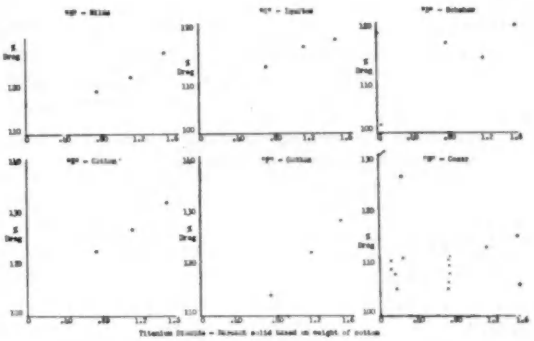


Fig. 4. Gain in drafting force of cottons treated with titanium dioxide vs. untreated cottons as affected by per cent solids added.

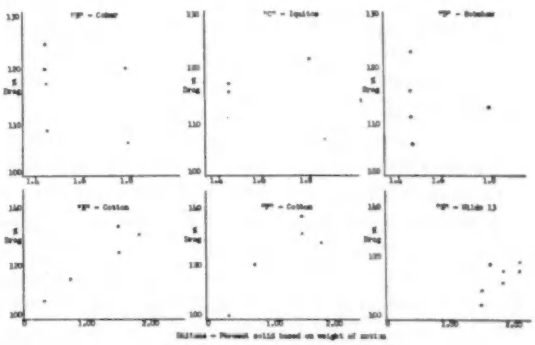


Fig. 5. Gain in drafting force of Unitane-treated vs. untreated cottons as affected by per cent solids added.

torque to the movable arm carrying the drafting rolls. Therefore, the only force contributing torque to the movable arm is the drafting force in the cotton.

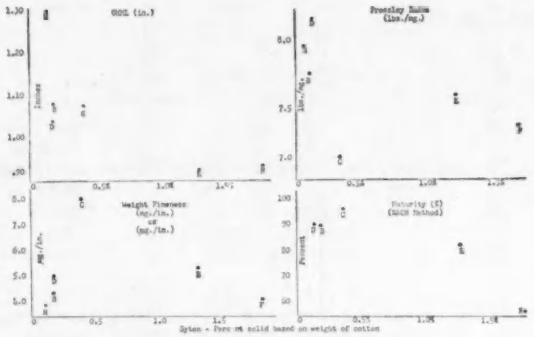


Fig. 6. Effects of per cent solids added (Syton) on cotton fiber properties for maximum drafting force.

The output of the strain gage is amplified and recorded so that both the average drafting force and its variation are recorded on the recorder charts. Calibration is made by weights, string, and pulley.

The charts were read at 75 equally spaced intervals to determine the average drafting force. The force for the treated sample was then divided by the force for its control to obtain the per cent of normal performance.

In Figures 2 to 5 the drafting force or drag, as per cent of normal, is plotted against the per cent solids applied from various concentrations of four additive treatments (Syton only, Syton plus additives, Titanium Dioxide, and Unitane) to each of six varieties of cotton. ("Unitane" is a commercial preparation of titanium dioxide possibly having some surface-acting agents included.) Syton, a commercial type of colloidal silica, was selected because it was readily available (on hand) rather than because of any possible superiority over other commercial compounds of similar chemical composition.

From these figures it is seen that the amount of compound required to produce maximum drag varies greatly for different cottons with lesser amounts being required for Syton than for the other two compounds. From an economical point of view preparations of colloidal silica would be more practical than those of titanium dioxide, and, therefore, it was decided to limit the further studies to these compounds.

In Figure 6 the per cent solids of added Syton that gave maximum drafting forces for the six cottons are plotted against several cotton properties: upper-half mean length, fineness, Pressley strength, and maturity. It is noted that there is an apparent inverse relation between fiber length (U.H.M.L.) and per cent solids required to produce maximum drafting force. There is no apparent correlation between per cent solids added and the fiber properties strength, fineness, and maturity.

Figure 7 is a similar chart for Syton plus surface-active mixtures of propylene glycol, Triton, and Proxol. With the surface-active agent added, there seemed to be a definite trend toward greater amounts of the preparation being required for cottons having lower Pressley index, but there was no noticeable trend in relation to staple length, fiber fineness, or maturity.

A comparison of Figures 6 and 7 shows that, whereas for Syton alone there was a general trend toward greater amounts being required with shorter staple lengths, this trend was not nearly so pronounced when the surface-active material was added to the Syton. For Syton alone, there was also a slight trend toward more of the compound being required with lower Pressley index and lower maturity, but it happens that, among these six cottons, those having the shorter staple length were somewhat lower in Pressley index and maturity, so that possibly it cannot be said which one of these cotton properties is more effective in determining the amount of Syton needed for maximum drafting force. The use of Syton alone seemed to be equally as effective as, if not slightly better than, the use of Syton plus a surface-active agent. From a study of all the tests it seemed that colloidal silica was the best and simplest preparation to use. This, of

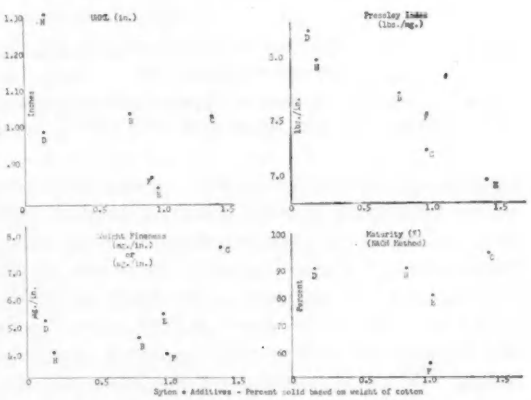


Fig. 7. Effects of per cent solids added (Syton plus additives) on cotton fiber properties for maximum drafting force.

course, is based solely on the criterion of maximum drag in drawing sliver, and there may be other factors that should be considered in deciding which compound is best.

Effect of Colloidal Silica on Processing Behavior and Yarn Properties

Three of the six cottons used in the limited study of the effect of additive chemical treatments on fiber properties were used in the assessment of comparable effects on processing characteristics and yarn quality. These three varieties were a Deltapine 15 (*A*), a Wilds 13 (*H*), and an unknown variety heretofore identified as cotton *F*.

An extensive study was made of such processing variables as draft, roll settings and weights, and twist at the various stages of manufacturing through spinning with a view to establishing optimum processing conditions for the treated cotton. Untreated and treated cottons were processed into 22/1 and 36/1 and 22/2 and 36/2 yarns. For the single yarns four twist multipliers were used with only the twist multiplier which resulted in maximum strength for each cotton being reported in this study. The ply yarns were processed from single yarns which were spun with the twist multiplier found to give maximum single yarn strength and 2-ply twisted with the same twist multiplier as used in spinning the single yarns.

The Syton was applied to the picker lap as it was being wound at the calender head. Four small sprayers were mounted above the calender rolls and operated at constant pressure, the amount of material applied being controlled by the strength of solution and the air pressure applied to the sprayers. A portion of each lap was left untreated to use as a control; and for each cotton both the control and the treated samples were carded and double drawn into 50-grain slivers under as nearly identical conditions as possible.

In the processing the following machines were used: Saco Pettee card with metallic clothing; Whitin 4-roll conventional drawing with cork-covered top rolls; Saco-Lowell F-S2 and Whitin Interdraft roving, and Saco-Lowell Roth and Whitin Casa-Blanca (F-2) spinning.

It was realized that standard machine settings for the control might not be optimum for the treated cottons and, therefore, roll weighting, roll spacings, draft proportions, total drafts, and twist multipliers at three or more values were tried for the treated stock. The procedure was to process the treated and the untreated stock through drawing with standard settings and then to run additional samples of the treated with higher and lower settings. To run the treated stock, first, with all other settings standard, three roll weightings were tried and selection was made on the basis of the best uniformity of drawing sliver. Likewise, three roll spacings were tested, and so on through draft proportion and total draft.

The whole procedure was repeated for each of two types of roving frames, using the most uniform sliver from drawing, and similarly repeated on two types of spinning frames, using the most uniform roving. At the spinning stage, evenness, skein strength, and single-end strength were all used as criteria for selecting optimum spinning organization. Control and treated yarns from both spinning frames were twisted into 36/2 and 22/2 yarns (with angle of twist the same as for singles) and tested for strength by both skein and single-end tests. On each yarn, skein break tests were made on each of 25 bobbins, all values being corrected to 36/1 and 22/1 and 36/2 and 22/2, respectively. Four single-end breaks were made for each of 25 bobbins, the samples being taken 10 yd apart after 120 yd had been used for the skein breaks. All tests were made under standard atmospheric conditions.

Nonunformity was measured at all stages by the Brush Uniformity Analyzer, running the stock at 10 yd per min with the sensitive length setting at 1 ft. Contrary to usual practice, the yarn was also fed at the slow speed to emphasize variations due to spinning only, minimizing the effect of long-term variation from previous processes.

Table III shows optimum machine settings and evenness values of drawing sliver produced by 4-roll conventional drawing frame using composition top rolls.

Table IV shows optimum machine settings and evenness values of roving produced by 4-roll conventional roving frame.

Tables V and VI show optimum machine settings and skein and single-end strength and evenness of yarns produced by two spinning frames.

An analysis of the data presented in Tables II through V reveals the following:

For cotton *A* there was no improvement due to silica treatment in either uniformity of slivers, rovings, or yarns, or skein and single-end strength of yarns. Generally, this cotton showed higher non-

TABLE III. Optimum Machine Settings and Evenness Values of Drawing Sliver Produced by 4-Roll Conventional Drawing Frame, Using Composition Top Rolls

Run	Roll Weight (lb) 1st	2nd	3rd	4th	Roll Settings* 1 & 2 (in.)	2 & 3 (in.)	3 & 4 (in.)	Total Draft (M.D.)†	Grain Sliver	Non-uniformity (%)
					Cotton *A*					
Control	22	18	18	18	1 1/2	1 11/16	1 7/8	6.10	49.6	14.07
Treated	30	22	22	22	1 1/2	1 11/16	1 7/8	6.10	50.1	13.37
					Cotton *F*					
Control	22	18	18	18	1 3/8	1 9/16	1 3/4	6.10	47.6	8.72
Treated	30	22	22	22	1 5/16	1 1/2	1 1/2	5.41	61.0	11.29
					Cotton *H*					
Control	22	18	18	18	1 11/16	1 7/8	2 1/16	6.10	50.7	4.14
Treated	30	22	22	22	1 5/8	1 13/16	2	5.41	65.1	4.18

	U.H.M.L.	M.L.	μg/in.	Pressley	Maturity (%)	Syton (%)
Cotton *A* (Deltapine)	1.11	0.91	4.5	7.6	—	0.12
Cotton *F*	0.90	0.77	4.0	7.2	56	1.8
Cotton *H* (Wilds 13)	1.30	1.03	4.0	8.0	—	0.12

* From center to center.
† Mechanical draft.

TABLE IV. Optimum Machine Settings and Evenness Values of Roving Produced by 4-Roll Conventional Roving Frame

Run	Roll Weight 1st	2nd	3rd	4th	Roll Settings* 1 & 2 (in.)	2 & 3 (in.)	3 & 4 (in.)	Draft (M.D.)† Front	Back	Total	Twist T.M.	T.P.I.	Hank Roving	Non-uniformity (%)
						Cotton *A*								
SL‡ Control	28	18	18	—	2 1/16	1 1/2	—	5.53	2.00	11.06	1.05	1.35	1.78	22.89
SL Treated	21	12	12	—	2 1/16	1 1/2	—	5.43	1.80	9.77	1.00	1.28	1.71	22.80
W§ Control	28	—	—	12	1 7/16	Fixed	1 5/8	3.77	2.78	10.48	1.05	1.36	1.87	27.57
W Treated	21	—	—	9	1 7/16	Fixed	1 5/8	3.85	2.53	9.74	1.00	1.29	1.59	23.20
						Cotton *F*								
SL Control	28	18	18	—	2	1 9/16	—	4.99	2.00	9.98	1.25	1.65	1.85	28.13
SL Treated	34	28	28	—	2 3/16	1 9/16	—	5.43	1.80	9.84	1.15	1.47	1.65	26.26
W Control	28	—	—	12	1 3/16	Fixed	1 3/8	3.77	2.78	10.47	1.25	1.65	1.86	29.63
W Treated	35	—	—	18	1 3/16	Fixed	1 3/8	3.85	2.53	9.74	1.10	1.41	1.64	27.19
						Cotton *H*								
SL Control	28	18	18	—	2 5/16	1 5/8	—	5.53	2.00	11.06	0.95	1.26	1.75	20.56
SL Treated	36	30	30	—	2 1/4	1 9/16	—	5.43	1.80	9.77	0.95	1.23	1.64	16.18
W Control	28	—	—	12	1 1/2	Fixed	1 11/16	3.77	2.78	10.48	0.95	1.25	1.77	19.77
W Treated	35	—	—	18	1 1/2	Fixed	1 11/16	3.85	2.56	9.86	1.00	1.28	1.72	14.43

Note: Cotton properties listed below Table III.
* From center to center. ‡ Saco-Lowell.
† Mechanical draft. § Whitin.

uniformity of product at nearly every stage of processing and lower strengths in the yarns for both skein and single-end tests. Possibly, the reason this cotton was not improved by the treatment was that the quantity of Syton may not have been optimum. Originally it was planned that the cottons for this study would be selected from the six used in the previous exploratory study. This cotton (*A*) is not one of the six but is most like the Coker 100 used previously, and the treatment was made like that which gave the highest draft for Coker 100. It is seen that different cottons require very different amounts of silica for maximum drag. Judging from the trouble encountered in processing this cotton and

TABLE V. Optimum Machine Settings and Skein and Single-End Strength and Evenness of Yarns Produced by Saco-Lowell 3-Roll Spinning Frame

Run	Roll Weight (lb)	Roll Setting* 1 & 2 (in.)	Roll Setting* 2 & 3 (in.)	Total Draft (M.D.)†	Twist T.M.	Twist T.P.I.	Skein Test Corrected Break	Skein Test Standard Error	Single-End Test Corrected Break	Single-End Test Standard Error	Non-uniformity (%)
				Cotton *A* (Saco-Lowell)							
36s Control	4.0	1 11/16	1 13/16	18.5	3.90	23.4	52.6	0.508	237.3	4.21	75.19
36s Treated	5.5	1 11/16	1 13/16	14.7	3.90	23.4	42.3	0.288	185.6	4.25	72.87
22s Control	4.0	1 11/16	1 13/16	12.8	3.90	18.3	102.5	0.957	398.3	5.83	62.12
22s Treated	5.5	1 11/16	1 13/16	10.2	3.90	18.3	82.4	0.737	319.5	4.96	62.62
				Cotton *F* (Saco-Lowell)							
36s Control	4.0	1 11/16	1 13/16	17.9	4.25	25.50	44.1	0.500	179.1	2.80	84.53
36s Treated	4.0	1 11/16	1 13/16	16.6	4.25	25.50	44.9	0.957	198.8	5.50	76.60
22s Control	4.0	1 11/16	1 13/16	12.5	4.25	19.93	74.6	0.816	337.2	4.78	65.94
22s Treated	5.5	1 11/16	1 13/16	10.2	4.25	19.93	91.1	1.814	369.4	7.11	61.04
				Cotton *H* (Saco-Lowell)							
36s Control	4.0	1 11/16	1 13/16	21.5	3.65	21.90	61.5	1.790	261.9	3.77	62.14
36s Treated	5.5	1 11/16	1 13/16	10.2	3.65	21.90	66.8	1.370	271.1	4.54	55.24
22s Control	4.0	1 11/16	1 13/16	13.0	3.65	17.12	124.5	1.414	460.0	5.24	47.19
22s Treated	5.5	1 11/16	1 13/16	15.1	3.65	17.12	125.4	1.815	476.7	6.14	48.40

Note: Cotton properties listed below Table III.
* From center to center.
† Mechanical draft.

TABLE VI. Optimum Machine Settings and Skein and Single-End Strength and Evenness of Yarns Produced by Whitin 3-Roll Spinning Frame

Run	Roll Weight (lb)	Roll Setting* 1 & 2 (in.)	Roll Setting* 2 & 3 (in.)	Total Draft (M.D.)†	Twist T.M.	Twist T.P.I.	Skein Test Corrected Break	Skein Test Standard Error	Single-End Test Corrected Break	Single-End Test Standard Error	Non-uniformity (%)
				Cotton *A* (Whitin)							
36s Control	4.5	1 13/16	1 13/16	17.8	3.90	23.2	62.2	0.671	247.1	4.93	71.86
36s Treated	4.5	1 3/4	1 3/4	22.4	3.90	23.2	42.7	0.706	191.2	3.46	73.04
22s Control	4.5	1 13/16	1 13/16	12.5	3.90	18.4	110.9	0.816	446.5	5.36	60.11
22s Treated	6.0	1 3/4	1 3/4	13.9	3.90	18.4	86.1	0.408	337.3	5.34	59.20
				Cotton *F* (Whitin)							
36s Control	4.5	1 13/16	1 13/16	17.2	4.25	25.50	41.0	0.240	186.3	3.58	81.31
36s Treated	6.0	1 3/4	1 3/4	15.4	4.25	25.50	45.9	0.935	208.4	4.49	67.39
22s Control	4.5	1 13/16	1 13/16	12.5	4.25	19.95	86.5	0.408	347.1	4.95	67.06
22s Treated	4.5	1 3/4	1 3/4	9.7	4.25	19.95	92.2	1.04	378.3	6.44	55.48
				Cotton *H* (Whitin)							
36s Control	4.5	1 13/16	1 13/16	19.9	3.65	21.92	63.7	0.816	264.3	4.81	61.59
36s Treated	7.5	1 3/4	1 3/4	23.6	3.65	21.92	68.3	0.957	256.6	3.62	58.75
22s Control	4.5	1 13/16	1 13/16	13.7	3.65	17.09	118.6	1.580	444.3	5.83	48.88
22s Treated	7.5	1 13/16	1 13/16	14.3	3.65	17.09	125.4	1.310	468.5	5.72	42.54

Note: Cotton properties listed below Table III.
* From center to center.
† Mechanical draft.

from the lower uniformity of the products, it may well be that less Syton should have been used on this cotton than was found best for the Coker 100 variety.

The staple length for this cotton falls between the staple lengths for the other two cottons, both of which, after treatment, processed into yarns of better uniformity and strength. The weight fineness of

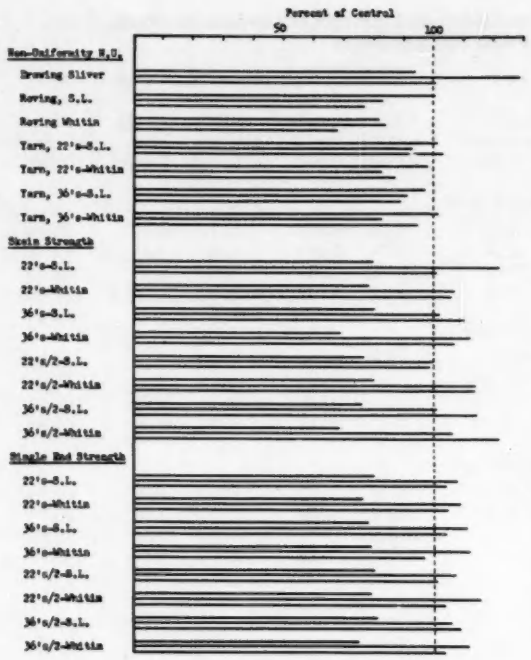


Fig. 8. Summary of effect of colloidal silica treatment on sliver, roving, and yarn uniformity and on skein and single-strand strength.

this cotton was slightly higher than that of the other two cottons, but this factor is not believed to have influenced the inferior performance of the treated samples of this cotton.

For cotton *F*, the silica treatment improved the evenness of slivers, rovings, and yarns as well as the skein and single-end strength of the yarns. The improvement was about the same for both 22/1 and 36/1 yarns. Since this cotton is considered to have a relatively short staple length and has a low maturity value and seems to show exceptional improvement in processing performance and in yarn quality due to this silica treatment, there may be an indication that this type of treatment has particular application to short-staple immature cottons. Possibly the short staple explains why the optimum percentage of silica is larger than for the other two cottons.

For cotton *H*, the silica treatment improved the evenness of slivers, rovings, and yarns and also improved the skein strength and single-end strength of the yarns. The improvement was about the same for both 22/1 and 36/1 yarns, and for both Saco-Lowell and Whitin machines. This cotton had the highest Pressley strength and longest staple and, as would be expected, gave the strongest yarns of any of the three cottons.

Figure 8 is a histogram showing the improvement (or impairment) of the processing characteristic and product quality of the three cottons due to applications of Syton. Each group of three lines refer to cottons *A*, *F*, and *H*, respectively. The lengths of the lines show the evenness or strength of the treated stock as a percentage of that obtained for the corresponding untreated control.

Table VII shows the comparison of skein and single-end strength of 2-ply yarns processed from treated and untreated cotton. Generally, improvements in 2-ply yarn strength, both skein and single end, result from application of Syton to cottons *F* and *H*, with little or no improvements in these properties resulting from application of Syton to cotton *A*.

Conclusions

The study seems to show that with cotton having a considerable range in physical properties definite improvements in processing result from the use of selected additives to increase the frictional characteristics of the fiber. Stronger, more uniform yarns can be produced and probably can be processed with fewer ends down in spinning.

It is very interesting that the improvement in processing is the greatest for cotton having the shortest staple. It should also be remembered that this cotton had a very low maturity. This fact may indicate that the use of frictional agents will allow the use of shorter cottons than would otherwise be practical.

Machine settings to produce optimum evenness are not very different from those for untreated stock except that higher roll weighting seems to be required.

The Saco-Lowell and Whitin roving and spinning frames showed nearly equal results on both 22/1 and 36/1 yarns. The instances of slightly superior performance were about equally divided between the two makes of machines.

It is interesting that, although drawing slivers from treated cottons *F* and *H* were less uniform than the controls, the roving and yarn produced are more uniform than the control.

In processing some lots wherein there were a higher number of ends down, stronger yarn was produced; and likewise, in certain cases where the evenness was lower, the yarns were somewhat stronger.

TABLE VII. Comparison of Skein and Single-End Strength of 2-Ply Yarns Processed from Treated and Untreated Cotton

Run	Roving	Spinning	Twist		Skein Test		Single-End Test	
			T.M.	T.P.I.	Corrected Break	Standard Error	Corrected Break	Standard Error
				Cotton *A*				
36/2 Control	SL	SL	3.90	16.49	139.7	1.46	500.1	5.85
36/2 Control	W	W	3.90	16.26	144.8	1.20	537.4	6.45
36/2 Treated	SL	SL	3.90	16.54	105.8	1.44	403.7	5.42
36/2 Treated	SL	W	3.90	16.40	99.1	1.16	403.2	5.61
22/2 Control	SL	SL	3.90	12.83	244.9	2.70	865.3	8.79
22/2 Control	W	W	3.90	12.83	248.5	3.32	916.3	8.46
22/2 Treated	SL	SL	3.90	12.93	188.1	2.77	693.7	8.06
22/2 Treated	SL	W	3.90	13.04	199.8	1.23	720.9	9.92
				Cotton *F*				
36/2 Control	SL	SL	4.25	18.03	108.6	0.87	408.6	4.85
36/2 Control	W	W	4.25	18.03	108.1	1.21	410.1	5.15
36/2 Treated	W	SL	4.25	18.03	109.3	1.58	433.2	4.61
36/2 Treated	W	W	4.25	18.03	114.1	1.68	459.0	7.53
22/2 Control	SL	SL	4.25	13.75	200.1	1.20	721.5	6.62
22/2 Control	W	W	4.25	14.09	187.5	2.18	693.3	7.86
22/2 Treated	W	SL	4.25	14.39	199.2	2.89	771.2	11.35
22/2 Treated	W	W	4.25	14.39	214.4	2.57	803.1	10.36
				Cotton *H*				
36/2 Control	SL	SL	3.65	15.48	143.4	1.64	549.3	6.66
36/2 Control	W	W	3.65	15.48	132.0	1.38	553.3	6.33
36/2 Treated	W	SL	3.65	15.48	165.0	0.68	596.3	6.20
36/2 Treated	W	W	3.65	15.48	161.0	2.23	576.2	5.91
22/2 Control	SL	SL	3.65	12.10	261.2	3.12	942.0	10.02
22/2 Control	W	W	3.65	12.10	245.7	3.55	969.7	8.77
22/2 Treated	W	SL	3.65	12.10	258.2	2.91	951.1	4.20
22/2 Treated	W	W	3.65	12.10	279.2	1.62	1010.5	8.84

Note: Cotton properties listed below Table III.

The study revealed the interesting fact that significantly different amounts of the frictional agent are required to produce maximum drafting force with different cottons.

Acknowledgment

Appreciation is expressed to twelve others of the Clemson textile staff who participated in the extensive work involved in this project.

Literature Cited

1. Anon, "Effect of Oil Spraying on Cotton and Spinning Process," *Indian Textile J.* **60**, 311–313 (January 1950).
2. Brown, R. L., "Colloidal Silica Aids Woolen and Worsted Spinning," *Textile World* **98**: 8, 123, 206, 208, 210 (August 1948).
3. Harrison, J. W., "Field Work with Colloidal Silica," National Cotton Council of America, Cotton Research Clinic, 37–39 (1952).
4. Hobbs, A. A., "Mill Application of Colloidal Silica to Cotton," National Cotton Council of America, Cotton Research Clinic, 40 (1952).
5. Langston, J. H., and Rainey, W. T., Jr., "A Literature Survey on Fiber Friction," TEXTILE RESEARCH JOURNAL **24**, 643–653 (1954).
6. Morrow, J. A., *J. Textile Inst.* **22**, T425–40 (1931); also in *Shirley Inst. Mem.* **10**, 35–49 (1931).
7. Murray, E. A., Moore, J. W., and Williams, S., "Studies of the Treatment of Cotton in Sliver Form; I and II: Effect of Syton," TEXTILE RESEARCH JOURNAL **17**, 331–339, 616–621 (1947).
8. Powers, D. H., and Harrison, W. J. (assigned to Monsanto Chemical Co.), U. S. Pat. 2,443,512 (June 15, 1948) and 2,527,329 (October 24, 1950).
9. Schmidhauser, O., and Stoll, R., *Klepzig's Textil-Z.* **41**, 103–114 (1938); abstract in *J. Textile Inst.* **29**, A298–9 (1938).
10. Scott, M. J., "Colloidal Silica in Cotton Spinning," National Cotton Council of America, Cotton Research Clinic, 35–36 (1952).
11. Smith, E., "Syton in the Textile Industry with Particular Reference to Woolen and Worsted Spinning," lecture to Huddersfield Textile Society, December 3, 1951, 24 pp., processed; abridged in *Textile Mfr.* **78**, 69–72 (February 1952).

The Effect of Fabric Structure on Fabric Properties

John J. Brown and Ralph A. Rusca

Southern Regional Research Laboratory,[1] New Orleans, Louisiana

Abstract

Research leading to the development of specialized fabrics for an agency of the Department of Defense is described. Requirements called for the fabrics to be highly resistant to the passage of water and air and to possess relatively high tensile and tear strength, yet to be light in weight.

The effects of 7 types of fabric structure on the physical properties of the fabrics are discussed. Of the constructions tested, basket weaves offered an acceptable compromise among the properties desired, with a 2/2 basket being highly water resistant without any chemical treatment and a 3/3 basket being slightly less water resistant and slightly more tear resistant. Regardless of the weave, as the picks per inch were increased, air and water resistance increased and tear strength decreased.

Bleaching, mercerizing, and dyeing significantly decreased the tightness of the fabrics; however, application of a flame-retardant and water-repellent treatment almost restored the original resistance of the fabrics to the passage of water and air.

Introduction

Although it has long been known that the physical properties of fabrics depend to a large extent on the weave, yarn construction, and other structural details, only within the past few decades has emphasis been placed on engineering fabrics for specific end uses. Perhaps the most widely known work of this nature was done by Peirce [4, 5], in which he presented formulas for finding the cover factor and other important constructional details of a fabric. More recently, a report published by the Office of the Quartermaster General, Research and Development Division [1, 3], included studies of the factors affecting the tear resistance, water resistance, air permeability, strength, and other physical properties of fabrics.

The Southern Regional Research Laboratory, at the request of the Bureau of Aeronautics, Department of the Navy, recently undertook the design and construction of a cotton fabric possessing certain physical properties highly desirable in specialized flight clothing. It was required that the fabric be light in weight and vapor permeable, and at the same time be highly resistant to water and wind, and possess relatively high tensile and tear strength. Also, the cotton varieties and yarn numbers to be used in such a fabric had to be readily available in time of a national emergency.

The research plan was to weave several fabric constructions from the same yarns and then to determine which construction would satisfy the end-use requirements. One important objective of the project was the development of a fabric which would possess the necessary properties without requiring any coating other than the conventional finishing operations. To obtain a highly water- and air-resistant fabric, it was necessary to use the SRRL loom attachment in the weaving process in order that the required number of picks per inch could be put into the cloth. Details of the construction and operation of this attachment have been published [2]; engineering drawings of the attachment are available from the Southern Regional Research Laboratory.

In designing a high density fabric where the pick-age is increased above the limitation of a regular loom, it is necessary to have sufficient ends per inch in the fabric to hold the width of the fabric as near as possible to that of the spread-in-reed. For the same cover factor, the weight of the fabric determines the ends per inch and the yarn number that are to be used. For a light weight fabric there would be more ends per inch and finer yarns than there would be for a heavier fabric.

A cover factor of 30 for the warp and 21 for the filling was selected on the basis of Laboratory experi-

[1] One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

TABLE I. Effect of Weave at Maximum Pickage on Fabric Properties

Fabric Type	Thread Count		Weight	Tongue Tear Strength		Air Permeability	Hydrostatic Head
	Warp Per Inch	Filling Per Inch	(oz per sq yd)	Warp (lb)	Filling (lb)	(cu ft per sq ft)	(cm of water)
Mock leno	188	100	5.79	*	4.8	2.76	20.1
6-Harness diamond twill	188	104	5.97	4.9	3.9	3.07	26.3
3/3 Steep twill	188	217	7.89	4.1	4.2	<0.61†	57.3
3/3 Basket	191	210	7.70	7.8	7.2	<0.61†	59.3
2/2 Regular twill	189	135	6.57	5.5	3.5	0.78	43.1
2/2 Basket	188	165	7.15	5.6	4.0	0	100.3
Oxford	194	121	6.37	5.5	2.8	0	105.7

* Tore across filling.
† Machine not calibrated to read less than 0.61 ft^3/ft^2.

ence with fabrics which showed good weaving performances coupled with excellent water-resistance properties. To meet the weight requirement, 80/2 combed cotton yarns were selected for both the warp and filling, with 190 ends and 134 picks per inch. The warp was drawn in on 12-harness, straight draw, so that the effect of different weaves could be studied without having to redraw the warp. In Figure 1 are shown the different weaves of the fabrics woven.

Results

Table I shows the physical properties of 7 fabric constructions, with maximum pickage for each weave. With the aid of the loom attachment, it was possible to produce the filling and total cover factors shown in Table II. Incidentally, to the best of the authors' knowledge, total cover factors in excess of about 52 have not been achieved heretofore.

On the basis of tear strength, air permeability, and hydrostatic head, the 3/3 basket and the 2/2 basket were found to be the best of the 7 patterns used. The hydrostatic head of the mock leno and the diamond twill was too low. The oxford showed a very good hydrostatic head and no passage of air at ½-in. pressure; however, the tear in the filling direction was low, as it was also in the 2/2 regular twill. Sufficient yardages of the 3/3 basket with 210 picks and 2/2 basket with 165 picks were woven and furnished to the Navy for in-service testing.

A detailed study was made of the effect of changing the picks per inch on fabric properties of the 3/3 basket, the 3/3 steep twill, and the 2/2 basket. Picks per inch were varied from 134 to maximum for each weave.

TABLE II. Filling and Total Cover Factors for 7 Weaves

Weave	Filling Cover Factor	Picks	Total Cover Factor
3/3 Steep twill	34.4	217	64.1
3/3 Basket	33.2	210	63.4
2/2 Basket	26.0	165	55.8
2/2 Regular twill	21.4	134	51.3
Oxford	19.1	121	49.8
6-Harness diamond	16.5	104	46.2
Mock leno	15.8	100	45.6

Effect of Picks Per Inch on Tensile Strength

Figure 2 shows the effect of increasing the pickage on warp tensile strength. The warp tensile strength decreases for the 3/3 steep twill and 2/2 basket with increases in picks per inch. This effect may be attributed to abrasive action on the warp during weaving. Although the 3/3 basket at 210 picks did not follow the same pattern, it is believed this is an error. Unfortunately there was insufficient fabric available to allow rechecking the data.

Figure 3 shows the effect on the fabric filling strength of increases in picks per inch. As would

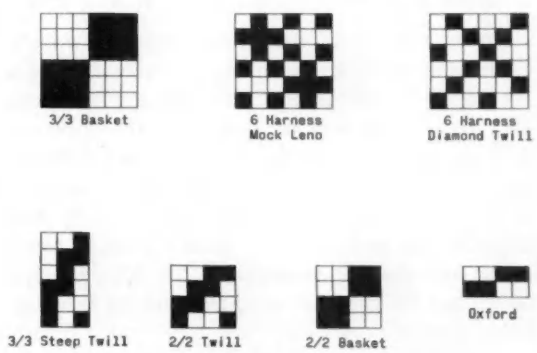


Fig. 1. Designs of weaves investigated.

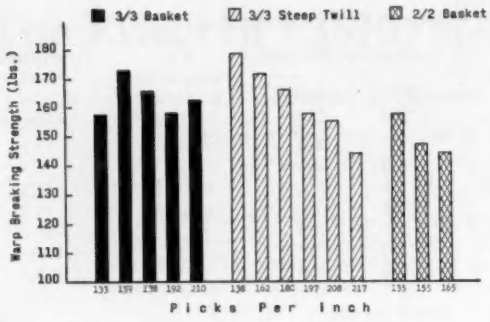


Fig. 2. Effect of picks per inch on warp tensile strength of three weaves.

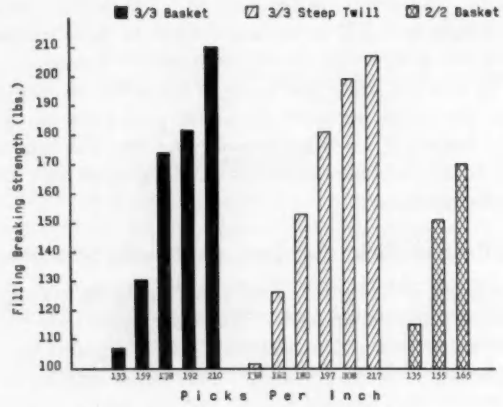


Fig. 3. Effect of picks per inch on filling tensile strength of three weaves.

be expected, the strength increased as the picks were increased.

Effect of Picks Per Inch on Tear Strength

The tear strength for the 3/3 basket was the highest in both the warp and filling (Figures 4 and 5). As might be anticipated, increasing the picks per inch lowered the tear strength in all three weaves. It is interesting to note that the 3/3 basket with 210 picks per inch had only 0.4 lb lower tear strength in the warp direction and 0.5 lb in the filling than the 3/3 steep twill with 138 picks per inch. Compared with the 2/2 basket with 135 picks, the 3/3 basket had 0.8 lb higher warp tear and 2.3 lb higher filling tear.

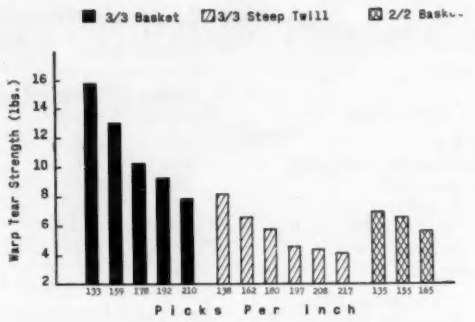


Fig. 4. Effect of picks per inch on warp tear strength of three weaves.

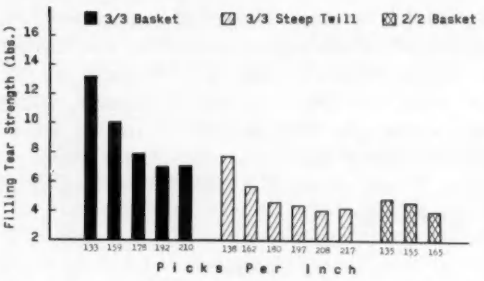


Fig. 5. Effect of picks per inch on filling tear strength of three weaves.

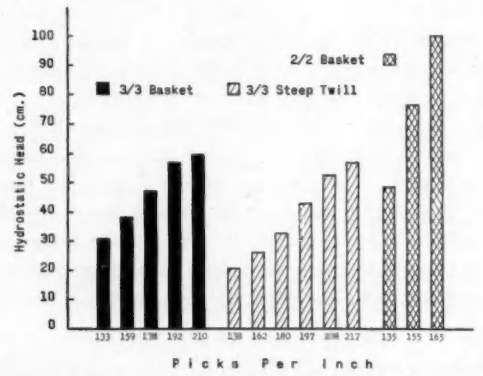


Fig. 6. Effect of picks per inch on hydrostatic head of three weaves.

Effect of Picks Per Inch on Hydrostatic Head

Figure 6 depicts the effect of increasing the picks per inch on the hydrostatic head. The 2/2 basket

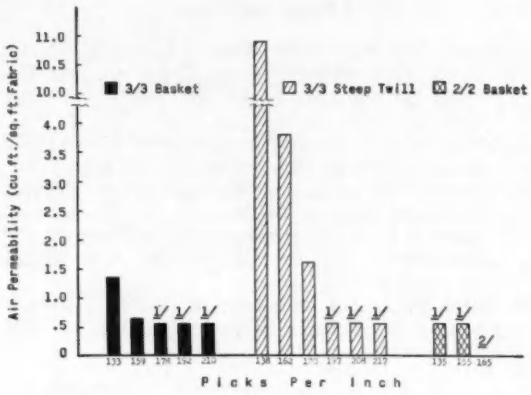


Fig. 7. Effect of picks per inch on air permeability of three weaves. 1 = machine not calibrated to read less than 0.61 ft^3/ft^2. 2 = zero.

weave with 165 picks per inch had 85% higher water resistance than either the 3/3 steep twill with 217 picks per inch or the 3/3 basket with 192 picks per inch.

Effect of Picks Per Inch on Air Permeability

Figure 7 shows the amount of air passing through the fabrics with increasing picks per inch. Like the effect on water resistance, the 2/2 basket passed less air at lower picks per inch than either the 3/3 basket or 3/3 steep twill at higher pickages.

Effect of Finishing on Physical Properties

After selecting the specific construction of the 3/3 basket and the 2/2 basket fabrics to be furnished for in-service testing, these fabrics were desized, scoured, bleached, mercerized, and dyed. The dyed fabrics were then given a flame-retardant and water-repellent treatment. Table III shows the effect of finishing through dyeing on the physical properties of the fabrics, and the effect of the flame-retardant and water-repellent treatments on vapor permeability and on air and water permeability. Although finishing significantly decreased the resistance of the fabrics to the passage of air and water, the subsequent treatments improved these properties so that they were almost equal to the grey goods. The treated fabrics were slightly less vapor permeable than the grey fabrics.

Summary

Knowledge of the effect of fabric structure on fabric properties was used as the starting point for developing a specialized cotton fabric required by an agency of the Department of Defense. It was necessary that the fabric be practically water- and windproof, yet be light in weight and possess adequate tear strength. Within the weight limitation imposed, it was found that the fabric could be produced from a high-sley, high-pickage construction with a very high cover factor. The desired warp

TABLE III. Effect of Finishing on the Physical Properties of High-Pickage Fabrics

Properties	3/3 Basket			2/2 Basket		
	Grey	Finished*	Treated†	Grey	Finished*	Treated†
Thread count (in.)						
Warp	191	204	207	188	198	200
Filling	210	200	193	165	158	161
Weight (oz/sq yd)	7.7	7.2	8.6	7.2	6.4	7.9
Strength (lb)						
Tensile (1" strip)						
Warp	162.7	172.0	149.0	143.9	157.0	138.0
Filling	210.6	144.4	144.0	170.0	138.0	146.0
Tear (tongue)						
Warp	7.8	9.7	4.2	5.6	5.7	3.6
Filling	7.2	8.6	5.3	4.0	5.8	3.3
Vapor permeability ($g/m^2/hr$)	29.6		27.3	30.4		28.1
Air permeability ($ft^3/min/ft^2$)	<0.6‡	5.2	0.8	0.0	4.1	0.0
Hydrostatic head (cm)	53.8	19.8	49.4	100.3	21.9	75.2

* Desized, scoured, bleached, mercerized, and dyed.
† THPC flame-retardant and "Zelan" treatment added.
‡ Machine not calibrated to read less than 0.61 $ft^3/min/ft^2$.

count was achieved through the use of fine, plied yarns, and the filling count through the use of a loom attachment developed several years ago by the Southern Regional Research Laboratory.

Acknowledgment

The authors gratefully acknowledge the assistance of the Testing Unit, Analytical, Physical-Chemical and Physics Section, for testing the physical properties of the fabrics and of the New Products Unit and the Product Development Unit, Cotton Chemical Finishing Section, for finishing, dyeing, and treating the fabrics.

Literature Cited

1. Harris Research Laboratory, Washington, D. C., U. S. Quartermaster Corps, Research and Development Division, *Textile Ser. Rept.* 37, 186 pp. (1951).
2. Mayer, M., Jr., Kyame, George J., and Brown, John J., *Textile World* **102**, 7, 114–115, 210 (1952).
3. O'Brien, William E., and Weiner, Louis I., TEXTILE RESEARCH JOURNAL **24**, 241–250 (1954); also published as U. S. Quartermaster Corps, Research and Development Division, *Textile Ser. Rept.* 81, 21 pp. (1953).
4. Peirce, F. T., *J. Textile Inst.* **28**, T45–96 (1937).
5. Peirce, F. T., TEXTILE RESEARCH JOURNAL **17**, 123–147 (1947).

The SRRL Carding Cleaner

George J. Kyame and Mayer Mayer, Jr.

Southern Regional Research Laboratory,[1] New Orleans, Louisiana

Abstract

A detailed description is given of an experimental machine somewhat similar to a downstroke buckley-type cleaner, but with the customary beater replaced with a licker-in type of carding cylinder. Also described is an improved feed system using a novel type of roll, called an "anti-pluck" roll. The new feed roll permits rapidly advancing a relatively thin layer of cotton to the carding cylinder, while simultaneously resisting the efforts of the carding cylinder to pull the cotton away. This results in opening the cotton to such a degree that cleaning efficiencies as high as 60–78% in a single machine are feasible at production rates of 400 lb per hr. Data are presented to show the performance achieved in a quarter-size experimental machine.

Introduction

It is well known that within the last few years the quantity of mechanically harvested cotton reaching the textile mills has materially increased. Whereas in 1948 only 750,000 bales were harvested by machines, it is estimated that at least one quarter of the 1954 crop, or about 4 million bales, have been so harvested. It is quite apparent, therefore, that mechanically harvested cotton is being marketed in ever-increasing quantities.

The trash content of some of this machine-picked cotton, particularly that which has been roughly harvested, is quite high, and although ginning reduces it considerably, there is still enough trash left to present a serious problem to the textile industry. In view of this, the Textile Machinery Development Unit of the Southern Regional Research Laboratory has been concerned with the development of equipment and methods for cleaning such cotton. Several methods of attack are being explored. Ultrasonic, electrostatic, aerodynamic, and the more conventional mechanical means have been, or are being, investigated. The investigations aimed at improving the mechanical methods have led to a promising experimental machine, the SRRL Carding Cleaner.

[1] One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

Development

The Carding Cleaner had its inception in an attempt to modify a conventional downstroke-type

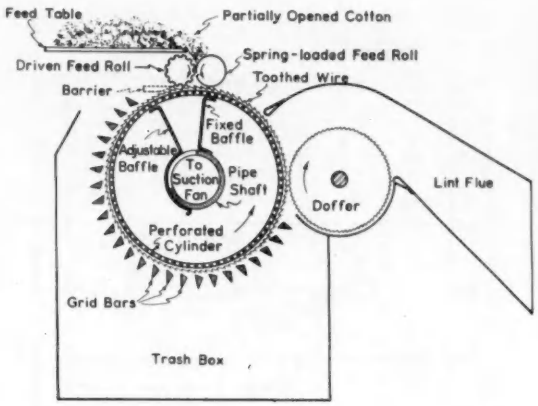


Fig. 1. Schematic drawing of the experimental unit.

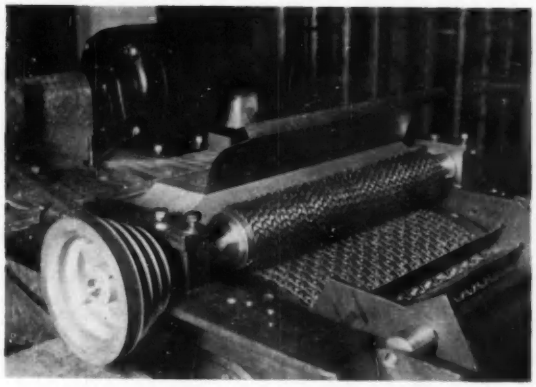


Fig. 2. Closeup of anti-pluck feed roll.

cleaner by replacing its porcupine beater with a perforated toothed carding cylinder. It was theorized that as the cotton was opened on being taken from the feed rolls, some trash would be released and would be drawn through the perforations by suction created in the interior of the cylinder. A schematic drawing of the experimental unit is shown in Figure 1. The carding cylinder was 13 in. in diameter by 13 in. long and was perforated with $^{15}/_{32}$ in. holes drilled in a path that spiraled around the surface at the rate of 2 turns per in. The cylinder was covered with a standard licker-in wire wound so that the wire bridged the perforations along the spiral path. Adjustable baffles limited the particular area of the carding surface subjected to the suction. The feed rolls directly above the carding cylinder consisted of one fixed, positively driven, fluted roll and one smooth, spring-loaded, friction-driven roll. Twenty-eight triangular grid bars, mounted on 1 in. centers, encircled the cylinder, starting near the fluted roll and ending just before the doffer. The doffer was a wire-wound cylinder covered with a wire having negatively raked teeth.

In operation, partially opened cotton was advanced by the feed rolls to the carding cylinder which, due to its higher surface speed, drafted the advancing cotton. However, since the nip of the feed-roll pair was at least 1½ in. away from the cylinder, the cotton was plucked in large clumps which went through the machine in a state that precluded cleaning. To counteract the plucking a knife-edged barrier was installed on the downstream side of the feed roll-carding cylinder nip. The detrimental effects of plucking were reduced considerably, but this arrangement was believed to have strong nepping potentialities because of the packing and possible rolling of the plucked fiber clumps. The smooth feed roll was therefore replaced with a spring-loaded sliding feed plate, and the fluted roll was cross-grooved to give it a waffle-ironlike surface. These changes eliminated the knife-edged barrier, but the solution was not completely satisfactory. The problem was finally solved by using a licker-in type of feed roll having two sets of teeth pointed in opposite directions.

Figure 2 is a closeup view of this "anti-pluck" feed roll being used in conjunction with the spring-loaded feed plate. The function of the feed plate here was twofold: first, to prevent the premature engagement of the carding-cylinder teeth with the tufts of cotton being advanced, and second, to anchor the cotton onto the feed-roll teeth. This arrangement not only prevented plucking, but it also resulted in opening the cotton to an extremely high degree, and with no damage to the fibers due to plucking from a tightly held tangled mass of fibers.

Several conclusions, some of which were expected, were drawn from the various trial runs made in developing the machine. First, a condenser-type carding cylinder is unsatisfactory for cleaning cotton. All attempts to suck such trash particles as leaf, stems, seed fragments, motes, and the like through the perforations failed; essentially all that went through were the shorter cotton fibers and dust. Second, to achieve cleaning efficiencies greater than 30%, the grid bar to beater teeth clearance has to be $^{1}/_{16}$ in. or less. Third, cleaning efficiency increases with increased spacing of the grid bars.

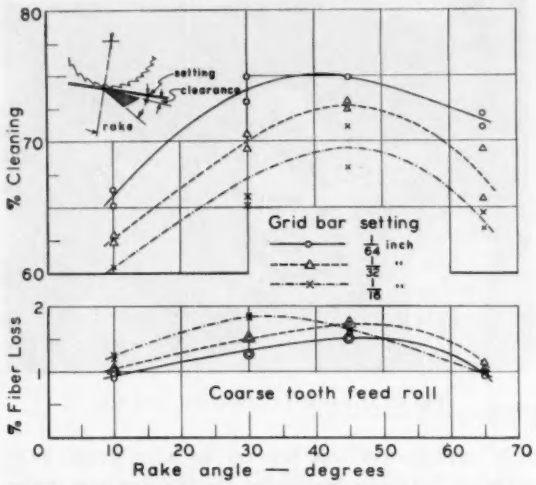


Fig. 3. Effect of grid-bar tilt angle and setting on cleaning efficiency and fiber loss. (Coarse-tooth feed roll.)

Fourth, decreasing the included angle at the leading edge of the grid bar makes cleaning efficiency less susceptible to the angle of tilt of the grid bar. And finally, cleaning efficiency increases with increasing openness of the stock.

With the knowledge gained from the preliminary experiments, the machine was redesigned and rebuilt. The grid bar mounting means were refined to permit more accurate settings of both angle of tilt and clearance. A new carding cylinder, without perforations, was made and clothed with a finer-toothed wire in turns spaced ⅛ in. apart. A drafting feed system was incorporated in the unit so that cotton coming directly from the hopper feeder could be drafted to the relatively lighter density requirements of the cleaner. The drafting system failed, however, so it became necessary to design a preopening unit to feed the cleaning unit.

Preliminary tests with the improved machine revealed a high degree of opening of the cotton, so high, in fact, that the doffer being used was incapable of completely stripping the thin film of fibers on the carding cylinder even though the surface-speed ratio of doffer cylinder to carding cylinder was increased beyond practical limits. This inability to strip the carding cylinder caused considerable "pilling" in the opened and cleaned cotton; i.e., the cotton coming from the machine was mostly in the form of little soft balls of fiber about ¼ in. in diameter. Satisfactory doffing was finally accomplished by installing an air-blast nozzle similar to that used in cotton gins.

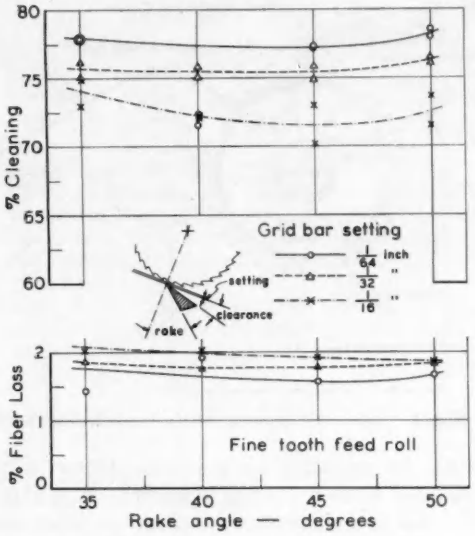


Fig. 4. Effect of grid-bar tilt angle and setting on cleaning efficiency and fiber loss. (Fine-tooth feed roll.)

Results

With the machine ready for formal evaluation tests, studies were made of the effect of grid-bar tilt and grid-bar settings on the cleaning efficiency of the unit. The results are given in Figure 3. It is apparent that maximum cleaning takes place at some rake angle between 35° and 50°. The decrease in cleaning observed at the 65° rake angle is believed due to the fact that at this rake angle there is no heel-to-toe clearance.

The feed roll, which had been covered with the relatively coarse standard licker-in wire, was reclothed with the same wire as was on the carding cylinder, and the tests were repeated to explore the previously mentioned grid-bar rake-angle range of 35°–50°. Figure 4 shows that with the finer teeth on the feed roll the cleaning rate has increased about 2–3% and that there is very little variation in cleaning within the rake-angle range tested. The lint content in the waste from these tests ranged between 1½ and 2% of the total weight of cotton processed, the lower fiber droppings being associated with the closer grid-bar settings. Plotted in Figure 5 are curves showing the distribution of the fibers according to length. These are based on Suter-Webb [2] fiber arrays made on samples taken from those tests

[2] The use of trade names does not constitute an endorsement of the product mentioned.

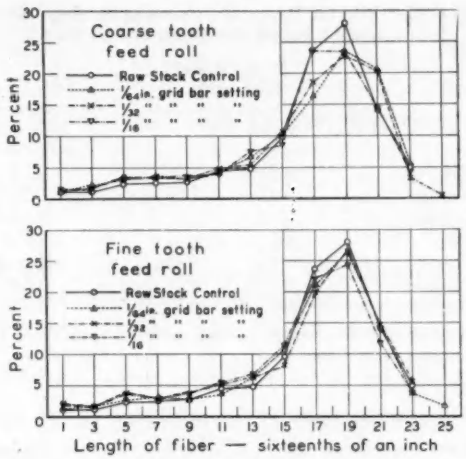

Coarse tooth feed roll
Raw Stock Control
1/64 in. grid bar setting
1/32 " " " "
1/16 " " " "
Fine tooth feed roll
Raw Stock Control
1/64 in. grid bar setting
1/32 " " " "
1/16 " " " "
Percent
Length of fiber — sixteenths of an inch

Fig. 5. Effect of grid-bar setting on fiber length.

which showed maximum cleaning for each of the three settings. The differences between the curves from the experimental tests and that for the raw stock control are considered negligible.

To explore further the possibility of fiber damage, a multiple-pass test series was run. The grid bars were set at 50° rake and 1/16 in. setting and four lots of raw cotton were processed. The first lot was put through the cleaner once; the second lot, twice; and so on. The cotton thus opened and cleaned was then processed twice through a finisher picker equipped with a Kirschner beater and formed into 13-oz laps, which were further processed into 4.2 hank roving and 36/1 yarn. While preparing the 4-pass lot, samples for fiber array determinations were taken during each pass. A comparison or control lot was put through a conventional mill line of one hopper-feeder, one Spirawhirl [2] cleaner, and one Downstroke [2] cleaner and was twice put through the aforementioned finisher picker. During the carding of the five laps, nep counts were made at the end of 4 lb and again at the end of 9 lb, with the exception of the 1-pass sample, which, because of a short picker lap, was taken at the end of 7 lb.

Figure 6 presents the resulting fiber-distribution curves. It is seen that although there are some changes in the distribution of the fibers according to their length, the amount of fiber damage indicated in the 1-pass sample is, for all practical purposes, negligible; that for the remaining samples is no greater than is experienced in the customary opening and picking line.

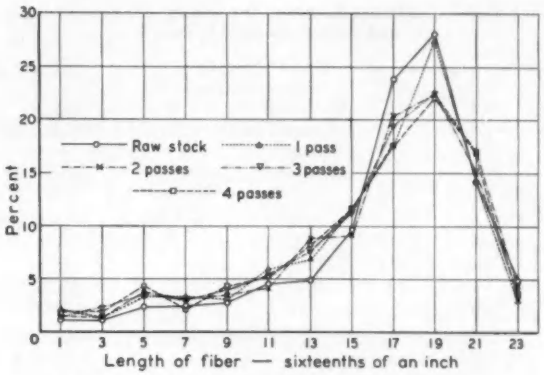


Fig. 6. Distribution of fibers by length after repeated processing.

Table I lists Pressley [2] strength data and nep counts. The Pressley tests show no significant differences in fiber strengths. The nep counts increased progressively with each passage of the cotton through the cleaner. It is believed that this can be corrected by a slight modification in the feed roll, and work along this line is in progress.

The yarn data are tabulated in Tables II and III. The effect of the processing on skein strength and yarn uniformity are seen in Table II. The skein-count strength products revealed losses ranging from 1.8–3.3%. Yarn uniformity was essentially unchanged. Similar results are observed in the single end strength data given in Table III. The count-strength product losses ranged from 0.52 to 1.2%. There was no significant change in strength uniformity for the first three lots, while some increase in uniformity was indicated for the fourth.

Conclusion

In conclusion, it may be said that the machine under development shows considerable promise.

TABLE I. The Effect of Repeated Processing on Fiber Strength and Neps

Test Conditions	Fiber Strength		Neps per Grain*	
	Pressley Index	Tensile (1000 psi)	After 4 lb	After 9 lb
Control	7.40	79.9	6.15	7.87
1 Pass	7.51	81.1	5.22	8.55†
2 Passes	7.41	79.9	6.20	11.42
3 Passes	7.46	80.5	10.92	16.71
4 Passes	7.48	80.8	18.81	21.83

* Carding rate, 10 lb per hr.
† Interpolated from 7.22 neps per grain after 7 lb.

TABLE II. Effect of Repeated Processing on Skein Strength and Uniformity of 36/1 Yarn *

Test Conditions	Skein Strength: Corrected Count-Strength Product (lb)	Skein Strength: Loss (%)	Uster† Uniformity: C.V. (%)
Control	2170	—	22.1
1 Pass	2103	3.1	22.4
2 Passes	2132	1.8	22.7
3 Passes	2099	3.3	22.9
4 Passes	2127	2.0	23.0

* Values are the average of two replicate tests from the same series of bobbins.

† Yarn speed through Uster, 8 ypm.

TABLE III. Effect of Repeated Processing on Single-Strand Strength and Strength Uniformity of 36/1 Yarn *

Test Conditions	Single-Strand Strength: Count-Strength Product (oz)	Single-Strand Strength: Loss (%)	Strength Uniformity: C.V. (%)
Control	286.5	—	12.79
1 Pass	285	0.52	12.15
2 Passes	285	0.52	11.63
3 Passes	283	1.2	12.29
4 Passes	284	0.87	11.36

* Values are the average of two replicate tests from the same series of bobbins.

The preliminary results presented are based on limited data; however, if these results are confirmed by a production-size machine which is now being designed, the SRRL Carding Cleaner will be capable of processing cotton at the rate of 400 lb per hr while removing about 70% of the trash present. It will accomplish this with negligible fiber damage. Recent research has shown that the machine can be modified to bring the lint losses within acceptable limits with little or no reduction in cleaning efficiency. There is reason to believe that future studies will lead to the elimination of the other deleterious effects that the machine seems to have.

An application for a U. S. Patent on the Carding Cleaner has been filed. If granted, the patent will be available for license in the United States on a royalty-free, nonexclusive basis.

Acknowledgment

The authors are indebted to the Processing, New Products, and Fiber and Fabric Properties Units of the Cotton Mechanical Processing Section for the preparation of the yarn samples and the analysis of the data obtained thereon. They wish also to recognize the work of the Testing Unit of the Analytical, Physical-Chemical, and Physics Section in performing the fiber arrays and yarn-strength tests.

Tek-Ja

A New Approach to Twistless Yarns[1]

Richard D. Wells

Bates Manufacturing Company, Lewiston, Maine

THE IDEA of staple fiber yarns held together with an adhesive agent instead of twist is not entirely new. Neither is the idea of using a temporary device to hold twistless or low-twist yarns together until they can be safely locked into a fabric. To date, however, there has been no major exploitation of a method or a product utilizing these principles.

The scope of this paper does not include a historical account of these developments. There is some mention and discussion of them in an article by Webster in the January 1955 issue of the British journal *The Textile Manufacturer* which is excellent background reading. Harold Chase of Dan River Mills in his challenging paper at an AATCC meeting over ten years ago stimulated considerable interest in bonded yarns, though the confusion of wartime emergencies robbed his paper of the attention it warranted.

My discussion is derived from our experience at Bates in the last two and a half years with the ideas and patented invention of the late Beardsley Lawrence. This development has been extended by and is assigned to Fiberbond Laboratories, Inc.

The Tek-Ja process is essentially the drafting of the strand to the desired weight; impregnation with the adhesive; rolling, compacting, and shaping by reciprocating rub-rolls; and drying and packaging.[2] Drafting is by conventional means with many possible variations. The drafted strand, still laterally dispersed as it leaves the front rolls, is delivered to the surface of the carrier or master roll which is wetted with a thin film of the adhesive mix. The transfer across the gap from the dry drafting element to the wet operation is effected by the spewing action of the front roll nip and the licking action of the wetted roll surface which is moving at the same or slightly greater speed. In some models the first wet roll is an intermediate carrier which the strand follows around and through a squeeze nip between it and a larger master roll. Roll surfaces and diameters are such that transfer is assured, leaving the nip, to the smoother and less curved master roll. In other models the master roll itself is the first wet contact. Clinging now to the master roll the strand passes under a series of smaller opposed rubbing rollers which reciprocate axially. The sliding nips work on the strand, shaping it stepwise and insuring completion of the impregnation.

The action of the rub-rolls is alternating, the stroke in one direction seeming to condense the strand, and the reverse stroke to partly open it again. The fibers slide laterally to some extent, opening and closing, and also roll and unroll to some extent. Relative amounts of rolling and sliding will vary with the type of fiber, the weight of the strand, roll pressures and surfaces, viscosity of the adhesive, and other variables. At each succeeding rub-roll, however, the degree of laterial spreading or unrolling is less, and is quite imperceptible at the final rub-roll. The yarn is fully shaped and compacted as it leaves the last nip. It is a feature of the Tek-Ja process, as now developed, that these rub-rolls are so spaced and so timed in their reciprocation that all sections of the strand receive practically equivalent rolling action. This is important in achieving uniformity of characteristics, and in attaining a good degree of roundness of the yarn. In our estimation this synchronization of multiple action is a key improvement over what we surmise had limited earlier developments.

I wish very explicitly to preface the balance of this discussion with the statement that our experience with the Tek-Ja process and yarns at Bates has been mostly with cotton, and almost exclusively with temporary adhesives such as polyvinyl alcohol. Our primary interest to date has been in applications

[1] The author requests that all inquiries concerning this work be addressed to Fiberbond Laboratories, Inc., Watertown, Mass., or to Proctor & Schwartz, Philadelphia, Pa. They should not be addressed to him nor to the Bates Manufacturing Company.

[2] For greater detail, see the paper by Powischill on page 486 of this issue.

where the adhesive is not needed in the final product and in most cases is not desired. Tek-Ja developments with other fibers or with permanent bonding agents may be of equal or possibly greater significance in the total program, but I cannot speak knowledgeably of them. What I have to say on this subject should not be considered necessarily valid for all fibers.

The development and evaluation of the Tek-Ja process involves three interrelated fields. One of these, the engineering of the equipment to do the job, is the subject of Powischill's paper.[2] My observations will deal with the processing and end-use characteristics of the yarns as we know them, and also to some extent with economic considerations.

The yarn as it leaves the drier and is wound on the package is stiff, brittle, and relatively fragile compared to normal spun yarn. The degree of stiffness, and the amount of strength, are in general proportional, though of course the characteristics of the adhesive have bearing on both. In low add-ons, however, there is a rather surprisingly small range within which the strength-stiffness ratio was varied. In these low add-ons only a bridging and cohesion between fibers is established and the stiffness of the adhesive itself is not paramount. Our work so far has used solids add-ons in the 4 to 8% range to avoid excessive stiffening and to keep the operation economical. In this range the yarn has sufficient strength for rewinding and some types of further processing and handling, and does not have unmanageable stiffness.

If there is a reasonable staple for the count and the process has been running well, such yarns can be transferred to bobbins and woven as fillings. Some adjustments in tensions, guides, conditioning, and possibly winding pattern may be necessary to make this fully practical, but no radical differences are presently indicated. The bonded twistless yarns do lie in the fabric slightly differently than would spun yarns, for the stiffness acts to lessen the amount of crimp which the yarn will accept at the beat-up and shed closing.

Twistless yarns have been knitted, again with some adjustments and preferably following application of a surface lubricant. Loop formation is slightly different because of relative stiffness, but it seems to be fully operable. Warp-knit materials have been made. We have not been successful in weaving twistless yarn as warp, the low elasticity of these yarns being probably just as much of a problem as the lower strength. I would not say that this is an impossible problem, but at this time the use of twistless yarns as weaving warps is one of the least promising prospects. The Tek-Ja yarns may be twisted and plied, and this process will be discussed later.

The Tek-Ja yarns are slick and free of fuzziness. They tend to be not quite as compact as equivalent spun yarns of normal twist, and are generally judged to be somewhat heavier than they really are. What strikes the mill man's eye most dramatically is their greater "apparent" evenness compared to spun yarns. Actually the linear weight distribution is little if any more uniform than would be that of spun yarn from the same roving and same drafting element. The difference is that, in having no twist, there is now no exaggerating effect of unequal twist distribution between heavy and light sections of the yarn. This suggests uses where evenness of appearance and bulk are of primary importance. Twistless yarns of this type have relatively little use except as components of combined structures or as intermediates towards other types of yarn.

The characteristics of the singles twistless yarn as woven or knit into fabric are the more interesting. First thought, of course, is consideration of strength. It has certainly been amply demonstrated that the lateral pressure of crimp and interlock in woven and knit goods serves just as well as and in some respects more efficiently than twist in preventing slippage of fibers and retaining yarn strength and continuity. A much longer paper than this could be devoted to the theory of the various factors affecting fabric strength, but I will mention only one aspect. The first is that in all our traditional concern over optimum twists and the like we are actually dealing only with the behavior of yarn as yarn, and the twists we put in in order to handle yarn efficiently are not necessarily the best if we are concerned primarily with fabric properties. There is a serious inherent strength inefficiency in a helical yarn structure. Furthermore, the combination of fabric crimp on top of twist, as in a conventional fabric, may be thought of roughly as the equivalent of increasing twist, and frequently of carrying twist far beyond the optimum range. Experimentally at least, we can say that twistless yarns in fabric have the same range of strengths as conventional materials and in some cases have significantly greater strength. It has been surprising

to find how low a construction can be made and still have the material hold together solely by crimp and interlock. It is also interesting that there is relatively little difference in the strength of the fabric whether the adhesive is left in or scoured out.

I should certainly recall here that reference to "strength" applies only to the single laboratory tensile test under an arbitrary rate of loading. What will happen under impact loading, or under repeated high loadings, may not be fully predictable from the simple tensile test. Experience so far, however, indicates good performance under repeated reasonable loadings, and shows that progressive slippage of fibers occurs only under rather violent conditions.

Since twistless yarns have very limited elongation under load, and in fabric can "give" only through crimp interchange and fiber stretch, the fabrics tend to be dead and inelastic. This, of course, makes them generally more stable dimensionally than their spun-yarn counterparts, which is advantageous or not according to the end usage. It does, of course, give a lower tear strength because of the lessened ability of the material to adjust itself and distribute the stress through a wider area. The differences found so far have not been of major magnitude, and may in some cases be compensated for by other features of the twistless yarns.

As to abrasion resistance, it would be unsafe to make any general prediction. It seems possible that under some conditions of abrasion the twistless yarns will outperform equivalent spun yarns because of a more favorable contact angle. Other conditions might reverse this. Since we have never made a fabric with twistless yarns in both warp and filling, the abrasion data we have is inconclusive because of the influence of the spun yarn component. So far we see nothing to worry about under mild abrasive conditions, as perhaps in garment wear.

Fabrics of twistless yarns with the adhesive removed are characterized by great suppleness of hand. In high-texture constructions which normally are stiff, the twistless version is quite flexible and drapey. One might even say "droopy," for zero twist yarns do not seem to be the answer to making highly resilient fabrics.

As to the effective bulk of the yarns once released of adhesive, the story seems to be that, where there is room to spread, as in knit and low-to-medium woven constructions, the twistless yarns will spread out and give improved cover. On the other hand the internal forces to cause bulking or spreading are of a low order and not very effective in further filling an already dense or jammed construction.

Just where this combination of physical characteristics will best fit into the variety of possible textile usages remains to be seen. Application will probably be where apparent evenness and smoothness, flexibility, or dimensional stability are significant. Possibly in some technical applications the low stretch and possibly higher strength may be exploited.

Going now to the low-twist yarns, in the range from zero up to and through minimum spinning twists, we find some rather intriguing factors. Through the Tek-Ja process, which provides a workable intermediate, it is now possible to run the whole twist range. So far, our work has been directed toward twisting the yarn in the dry state, but there are, of course, possibilities of damp or wet spinning which would be expected to modify the results through greater plasticity and freedom to adjust to the new configuration.

Most of the properties of the low-twist yarns with the adhesive removed will be found roughly proportional to the degree of twist, as one would predict. On the matter of the strength-twist ratio, however, there are some significant differences.

Figure 1 shows strength-twist curves for a 25's yarn in two different conditions. The top curve is typical for dry Tek-Ja yarn with the adhesive still present. Note the very rapid strength build-up with increasing twist, with a peak roughly at the 3 multiplier. The shape of this curve will vary considerably according to the type and amount of ad-

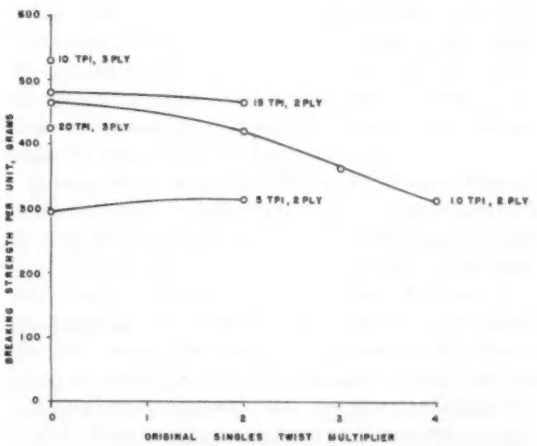


Fig. 1. Tek-Ja 25's single yarn strengths.

hesive. We have had cases where the peak is near the 2.25 multiplier with a distinct drop-off at 3. In general the curve will lie above that of the normal spun yarn, and will show appreciable strength at lower twists, a peak below the optimum twist for normal yarn, and a flatter section through the conventional twist range.

The second curve of the Tek-Ja yarn, with the adhesive scoured out following twisting, has some interesting characteristics. Of most significance, perhaps, is the quite respectable strength of these yarns in twist ranges from the 2 multiplier up. The curve does continue to climb up to around the 4 multiplier, but the percentage gain, as from 3 to 4, is surprisingly small. Unfortunately we did not get a curve plotted for normally spun yarns, so we will have to imagine this curve with a peak around the 3.90 or 4 multiplier. Since the whole strength curve of the scoured Tek-Ja yarn lies above this, it is indicated here and is a fair generality that the scoured Tek-Ja yarn at the 3 multiplier has strength as good as or higher than normal yarn at the latter's optimum twist. This, of course, is in terms of yarn strength alone. It is worth some thought, though, as to the "effective" strength of a yarn once it is in a fabric. As was mentioned before, if we impose crimp on top of what already is optimum twist for yarn, *as yarn*, we go beyond the optimum effective strength of the yarn *in the fabric*. It should be possible with the Tek-Ja process to use lower yarn twists which, with the additional locking action of crimp, will give practical fabrics of considerably higher fabric strength than conventional fabrics whose normal twists are beyond the optimum because of the action of crimp. There is experimental support for this concept, and I note that, in Webster's article previously mentioned, similar conclusions have been drawn. Though it would certainly be premature to enter such data in the textile handbooks, there is good indication that in many fabric constructions the maximum effective strength may be obtained with yarns of twist in the 2.25 multiplier range. Of course, this does not suggest that strength is the only attribute one should consider in selecting twist.

It would be well to consider for a moment the mechanics of staple-yarn strength, though perhaps at the risk of dangerous oversimplification. We all understand in a vague qualitative way that the positive effect of twist on yarn strength is that of increasing fiber-to-fiber contact area and contact pressure to prevent slippage and separation. The negative factor of twist on strength is the inefficiency of the helical structure due to the vector effect per se and also the disparatity in angle between fibers at differing locations of the cross section. The higher the twist, the lower the efficiency. At some point for any given yarn the positive and the negative factors cross to give the optimum strength balance. Qualitatively, theory and experience agree. Only in fairly recent work, however, have researchers begun to gain a quantitative idea of internal frictional forces in yarn structures. It seems logical that an increase in fiber-to-fiber contact area reduces the required contact pressure to attain equivalent "lock" and strength. In other words, the better the "fit" of the fibers the less lateral pressure is required; hence less twist. We conclude that the "fit" of the fibers in yarns made by the Tek-Ja process is more complete than that in normally spun yarn. This seems reasonable when one compares the rolling and squeezing action of the Tek-Ja process to the rather indeterminate snatching of fibers into the vortex of a yarn being spun in midair.

We do, then, consider twisted Tek-Ja yarns to be significantly "different" from regularly spun yarns of equal twist; and new rules will have to be developed for fabric organization in order to attain maximum benefit from them. Even assuming that for some uses no great reduction in twist would be desired for reasons of "hand," resilience, and the like, there is at least opportunity to put in the desired twist at higher speeds on modern twisters rather than being limited by the bottleneck of practical spindle speeds. Things are not quite as simple as that sounds, but at least we can now do something that was not practical before, and that is a challenge in itself.

Coming now to ply yarns made of Tek-Ja processed singles, we find in general a similarity in the rapid build-up of strength as twist is introduced. In plying yarns of previously untwisted singles it might seem at first thought that we would end with only a normal singles of the combined weight. This is not the case, however. As has been noted by other workers in spinning from separated front-roll deliveries when drafting double roving, there is a measurable improvement in strength over that normally obtained when the two strands are combined in the drafting. In simplest terms this serves to assure the "spirality" of each fiber in the yarn, thus lessening the *range* of helical angles of the several fibers and avoiding relatively straight fibers which

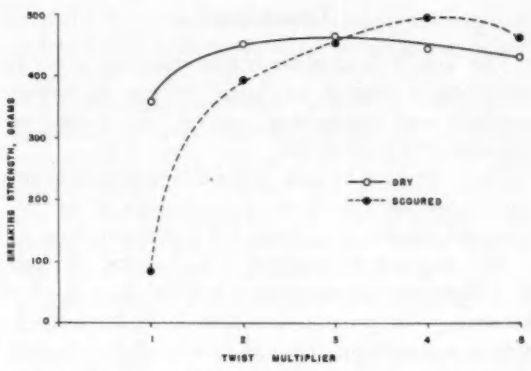


Fig. 2. Plied yarns made from Tek-Ja 25's singles.

are particularly vulnerable when load is applied to the yarn.

Our data on Tek-Ja ply yarns is still somewhat sketchy and includes some anomalies which are as yet unexplained. At one point we thought we had a nice consistent picture to show and a rather plausible theory to explain it. Then more experiments were run and now we are somewhat confused.

Figure 2 shows how erratic some results have been. This shows strengths of some combinations of singles and ply twists, all with adhesive removed after plying. We know of no satisfactory explanation why the singles at the 3 and 4 multiplier with the nominal ply twist of 2.83 look so poor compared to the zero twist singles in the same ply twist. It does seem plain that we will have to develop entirely new formulas for ply yarns starting from Tek-Ja singles. There is a real possibility that the optimum will be found in relatively low twists and quite different ratios of singles to ply twists compared to conventional yarn. It also seems quite certain that stronger ply yarns can be made of Tek-Ja singles than are now possible. This may even be accomplished with no original twist at all in the singles.

The discussion so far may have suggested applications for Tek-Ja yarns due to their specific technical features. There undoubtedly will be places where the Tek-Ja yarns will perform sufficiently better to warrant a premium over the cost of yarns which they might replace. There could be much wider utilization, of course, if the Tek-Ja version were cheaper than conventional yarn.

Since operator expense outweighs everything else, except material, in yarn manufacturing costs, it will take a mill-scale Tek-Ja operation to determine what cost league this process is in. All other factors being equal, it seems unlikely that the Tek-Ja process might generally replace conventional cotton spinning on a cost-per-pound basis. However, this is far from impossible and all factors do not necessarily have to be equal.

As to the operation itself, we must first face the fact that capital investment per end of delivery will be several times that of conventional spinning. There appears to be no way to beat that. Also inherent in the process are the expenses of the adhesive and the drying. It is also likely that ends per operator will be in the hundreds rather than the thousands, though that will depend in good part on the engineering investment.

On the favorable side we note first that the linear production rate per delivery end will be several times that of conventional spinning; we think at least three times the speed for medium counts, and maybe up to five times the rate of normal spinning. Also, fine yarns come zipping through the Tek-Ja process about as fast as coarse counts. Another advantage is that the initial package can be of any size. We wind to cheeses now, and there is no technical limit.

Now, as to things that do not necessarily have to be equal, there is first of all a real possibility of "getting by" with shorter than normal staple for a given count. We are not always as enthusiastic in this prospect as was one of our Tek-Ja operators. On a day when we were having a good run on 196's yarn from 1⅜-in. domestic stock, he challenged, "If you can make a draft head that will deliver single fibers end-to-end I will make a yarn from them."

We have had quite comfortable runs on 100's count from 1⅛-in. staple. Similar trials beyond the conventional spinning ranges given in the handbooks have been run—and not entirely as stunts. I will admit, however, that the work load involved a very small number of deliveries.

There is also some possibility of utilizing higher percentages of very short fibers than are tolerable in spun yarns. If the drafting element can feed these shorter fibers through in a fairly uniform manner, the Tek-Ja process will "fit" them into the yarn instead of letting them blow around the spinning room.

There are a few other minor economies which could be effected. It is at least conceivable that by taking maximum advantage of all economies the Tek-Ja process might make cheaper yarns to do the

same product job as regular spun yarns. Basically, the entire cost picture hinges on operator expense, and this cannot be predicted at this time. The problem is similar in many respects to that which faces the entire industry today. We are going to have to reevaluate all our equipment, methods, and costs in the light of today's and tomorrow's probable conditions. We must then try to strike a more favorable balance between the effort and expense of the research, design, building, and capitalizing of relatively foolproof automatic equipment, and the expense of a large labor force to serve and nurse traditional equipment which is far from automatic in a full engineering sense.

Conclusion

The Tek-Ja process for bonded twistless yarns is intriguing in concept, and opens the way to various products and production systems not heretofore demonstrated as practical.

There seems to be both technical and economic potentials for the Tek-Ja process; certainly in specialized, and possibly in general, fields of application.

As a growing development Tek-Ja is well through its infancy and approaching a healthy state of adolescence. We are confident that in its maturity it will be a significant factor in textile affairs, though the exact pattern is not, as yet, fully predictable.

Processing Equipment for Tek-Ja Yarn

John W. Powischill

Chief Engineer, Proctor and Schwartz, Inc., Philadelphia, Pennsylvania

UNDER license from the Fiberbond Laboratories, Inc., of Watertown, Mass., machinery is now being built by Proctor & Schwartz, Inc., to commercially manufacture no-twist yarn. The process of making the no-twist yarn is known as the Tek-Ja Process, (U. S. Pat. 2,689,813). This process is the invention of Beardsley Lawrence, who worked for a number of years before his death on its development. Patents have been assigned to the Fiberbond Laboratories, Inc.

During the years spent on the development of several pilot installations and the accompanying trial runs which were necessary for the present development of yarns and resultant fabrics, the original ideas concerning the process have changed but little. The basic elements of this system can best be illustrated in a line drawing (Figure 1) showing the following: (1) a creel to hold roving bobbins of the proper hank count; (2) a draw frame to reduce the roving to the proper yarn-count size; (3) an impregnating and forming device for applying an adhesive, either temporary or permanent, to the yarn; (4) a drying section for setting the adhesive; and (5) a winding or packaging device to take the formed and bonded yarn from the dryer and put it into a package suitable for future processing.

Auxiliary elements required for the process consist of a driving mechanism to synchronize the various units and a sizing system to prepare and properly

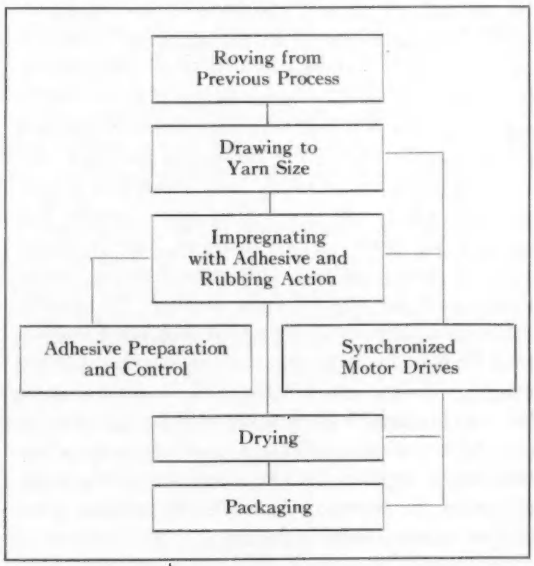


Fig. 1. Elements of TEK-JA Process for manufacturing no-twist yarn.

hold the sizing solution at the proper viscosity and to feed the size to the forming device in the proper amounts.

All these elements were present in the original conception of this process. None can be altered without destroying, or at least altering, the end product desired. However, the physical construction of the components in the machines have been altered as each successive pilot unit has been built. Therefore, the present machines, which we are now manufacturing for commercial installation, are considerably changed from the earlier pilot models. It is the development of the machinery for the Tek-Ja Process that the writer intends to discuss in the balance of this paper.

In undertaking the development of the machinery for commercial mill operation, it was realized that the following factors would have to be taken into account.

First, the machinery, while capable of producing a yarn of unusual properties, should operate competitively with conventional machines producing conventional types of yarn. It is conceivable that in many cases no-twist yarn made on the Tek-Ja Process may warrant a premium price, but it is hoped that the manufacture of no-twist yarn can be accomplished without extra cost. There are factors other than the machinery itself which tend to make the manufacturing cost of Tek-Ja yarns differ from conventional yarns. Some of these factors can be considered advantages. For example, yarn can be made from less costly fiber. Other factors, such as the cost of the adhesive, may appear on the debit side. However, the machinery itself should be of such a nature that the actual processing of the yarn will not entail excessive costs.

Second, the machine must be convenient and accessible. Some of the earlier pilot models required considerable gymnastics on the part of the operator in order to get the yarn completely through the process. Therefore it was felt that the machines for making Tek-Ja yarn should be built as completely automatic and accessible as possible, so that anything causing the breakage of an end could be quickly corrected. This led to design of equipment which we feel is compact. None of the individual elements of the machine is greatly removed from the others, and all of the elements of the machine are relatively easily reached by the operator. One of the most difficult problems confronting us has been in the design of the dryer since this unit has to be small, automatic, and trouble-free.

Third, the unit must be economical of floor space. This to some degree is a restatement of the second factor but goes beyond the second factor, and it led to our trying to use as much vertical space as possible. By making the units compact we also aided the accomplishment of one objective of the second factor, namely, that the units be convenient.

Fourth, and certainly one of the very important factors, the unit must economically justify its original cost. Certain readily available devices used on the pilot units and considered for use on the commercial machines proved to be too expensive, largely because they had been developed for a somewhat similar application but not specifically for this machine. A good example of this is the package winding frame where our requirement was for a unit with a very large holding capacity and a slow operating rate. Conventional units would have produced satisfactory packages but are designed for a relatively small holding capacity and a fast operating rate. As a result of this, we had to develop another packaging unit.

At this point the writer would like to state that much of the original thinking concerning the design and fabrication of the commercial equipment was done in conjunction with both Fiberbond Laboratories and the Bates Manufacturing Co. Many of the ideas ultimately incorporated in the final design for the machinery now being built by Proctor & Schwartz, Inc., were discussed by all three organizations in an effort to anticipate problems which would arise in the operation of the machinery. The Bates Manufacturing Co. has approached the problems from a slightly different standpoint and actually built a pilot unit which has been processing yarns in the laboratory. No real difference in opinion as to the theoretical performance of these machines has existed; rather Bates has attempted to prove certain points about which they felt more strongly than our own company did. We in turn endeavored to take alternate solutions and work them out. Since the Tek-Ja Process appeared capable of preparing a very wide range of yarns from various raw materials and producing yarns with either a permanent or temporary bond it was felt that some of the data developed as a result of these separate approaches will undoubtedly be used as machines are built for a wider range of products.

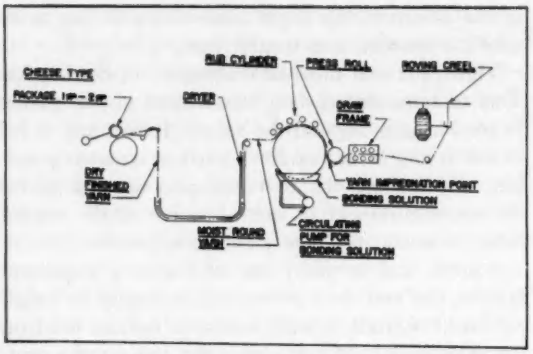


Fig. 2. Simplified arrangement of machinery for Tek-Ja Process no-twist yarn.

Figure 2 shows the arrangement of the machinery as it exists today. The balance of this paper will explain briefly each of the components shown in this drawing.

In Figure 2 it can be seen that we have provided a roving creel at the feed end of the unit, mounting the roving bobbins vertically on Eclipse bobbin holders so that the time required to load the creel is kept to a minimum. Since this unit is at the rear or entering end of the machine, it is felt that these roving creels may be loaded by a separate operator who would have charge of a whole battery of machines.

At the delivery end we have developed a packaging machine to make a cheese-type package approximately 3 in. in width and weighing between 1 and 2 lb, which would give a cheese of about 7 to 12 in. in diameter. This winder was originally built 4 banks high, but the top bank proved to be too high for practical use so this single 4-high unit is now being replaced with 3-high units. For coarse yarns, 1 unit of 51-package capacity can be used, whereas for fine yarns 2 units facing each other can be used. We hope ultimately to be able to make this unit self-threading, but at the present stage of our development the best we have been able to do is to lead the individual threads to a position close to the eye of the package-winding device. This package winder is of the surface type so that each package can be run independently of the others. Loading and unloading of this device can also be done by an individual other than the operator of the machine. It is believed that the same person who loads the roving bobbins can unload the packages.

The present development of the draw frame has consisted of using a Saco-Lowell DS-2 three-over-four two-delivery draw frame, altered to fit the Tek-Ja unit. By doing this, a large number of ends can be put up side by side with yarns being spaced as close as ¼ in. apart in some cases. With an 18-gage frame (12-in. working face) each delivery can handle a maximum of 50 ends of 70's count. The number of ends will be decreased as the yarn counts become coarser. Therefore this machine with a two-delivery 18-gage draw frame is rated at 100 ends, 70's count. This machine is actually one-half of a machine. We are now building several machines double this width, and these are rated as 200-end machines, 70's count yarn. While the draw frame used on the Proctor & Schwartz machines is normally the type used for drawing card sliver, good results have been obtained in drawing roving, but this problem has not been completely solved as there are limitations to the amount of draft that can be obtained with a single head of this type. Other types of draw frames are being investigated, and we are contemplating for the future the use of a draw frame which will reduce the card sliver directly to the yarn count required.

The mechanism for impregnating and forming the yarn consists of one large rubber-covered cylinder 16 in. in diameter and 30 in. wide. This is the one-half-machine width. The drawn roving is fed to this main roll from a rubber-covered press roll 8 in. in diameter. This press roll also has the adhesive upon its surface, and, as the drawn roving passes between it and the main roll, it is flattened into a ribbon and the extra adhesive is pressed out and returns to the sump. The flat ribbon, filled with adhesive, passes to a series of neoprene-filled cork-covered oscillating rolls so arranged as to rub every section of the ribbon. This action forms the ribbon into round yarn, and at the same time the adhesive is further applied to the individual fibers. There are 5 of these oscillating rolls, each 2 in. in diameter. Their action upon the yarn is in the form of a sine wave; when a number of sine waves properly spaced apart are added together the final result is practically a constant. Each of the 5 rolls is located to introduce a portion of the sinusoidal action at the proper point in the yarn so that the result of the action of the 5 rolls is to give each portion of the yarn an equal amount of rolling, thus forming a uniformly round yarn (Figure 3).

After leaving the last oscillating roll, the wet yarn is introduced into a tube type dryer. We hope eventually to make this transfer a completely automatic

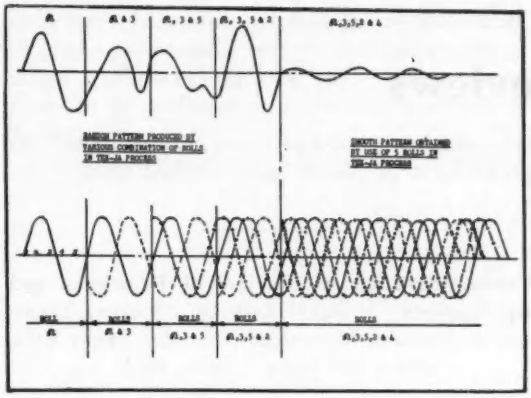


Fig. 3. Use of rolls in Tek-Ja Process.

one. Once in the tube the yarn is conveyed forward by an air stream which is circulated by suction on each tube. Enough initial drying must be done to prevent adhesive on the yarn from sticking to the tube side and subsequently fouling the tube. Final drying is done in the tube conveying the yarn to the winding frame. Work is in progress on the development of a unit to be used at the discharge of the tube which will discharge the yarn but reclaim the air coming through the tube to improve the efficiency of the dryer. The dryer is gas heated in order to get the high temperatures necessary for quick drying. Air can be preheated before entering the dryer tubes and additional heat can be transferred to the air by conduction and radiation of the tube walls. The use of gas also allows for quick shutoff of the heat in case it is necessary to stop the unit for any reason.

The synchronized drive for this machine is at present being accomplished through a variable-frequency generator unit driving synchronous motors on each of the elements of the machine in range. The main drive to the alternator is through a variable speed, and this same drive drives the reciprocating rolls. There are 3 other auxiliary motors: the draw frame, the main cylinder, and the winding frame, all synchronized to the main alternator. This drive has been developed by U. S. Electrical Motors, Inc. A ½-unit machine requires about a 7½-hp motor to operate it. It is estimated that a full-width machine will require a 10-hp motor.

At the present time it is contemplated that the impregnating solution will be fed to a battery of machines through a common mixing source to control temperature and viscosity. This is similar to the type of equipment used in slasher rooms. We have been experiencing some difficulties with polymerization of the impregnating solution as it passes through the pump, but progress is being made to eliminate this difficulty. It is planned to supply each individual machine with a surplus of impregnating liquid. This will be flooded onto the main cylinder, and the surplus will then be returned to the main sump, where it will be strained and reheated. The straining is to remove any lint which accumulates and which, if not removed, would give an uneven yarn surface, and cause fouling of adjacent ends.

The operating speeds of these machines will be from 15 to 40 yd per min. The machines are designed to run 40 yd per min, but to date no yarn has actually been produced at these speeds except in small quantities. However, we have made yarn at 15 to 30 yd per min. regularly, so we feel that we are not being optimistic in expecting 40 yd per min. eventually. From the above, it is apparent that one full-width machine having 200 ends could produce considerably more yarn per hour than a 200-spindle spinning frame. If one operator can operate 4 or more full-width machines, this process should be competitive with conventional spinning methods.

Our main efforts now are being devoted to solving various minor problems along with some larger problems which cause excessive down time and reduce the number of ends that an operator will be able to handle. Progress is being made in this direction. Naturally not everything is going as we had hoped it would, but then some things are going better than expected, so we feel that we are rapidly reaching the point where Tek-Ja Process yarns may be made at least as economically as commercial yarns.

We are now building several full-width machines which will be put into commercial operation. Yarns made on these machines will be offered for sale. As is often stated, "The proof of the pudding is in the eating." Once these units are running, we will know exactly how close we have come to our original objectives.

Book Reviews

Synthetische Wasch- und Reinigungsmittel. Helmut Stüpel. Stuttgart, Germany, Konradin-Verlag, Robert Kohlhammer, 1954. Available through Stechert-Hafner, New York. 568 pages. Price, $17.00.

Reviewed by Jay C. Harris, Monsanto Chemical Co., Dayton, Ohio

The author has successfully condensed the pertinent and up-to-date information on this specialized but rather broad field in a single volume. Not only are European techniques and products discussed, but also recent advances in the United States detergent industry are included.

The structure of the book is a logical one and leads naturally from structure and physicochemical properties to specific examples of surfactant type. A considerable section is devoted to synthesis, synthetic methods, and practical manufacture and is followed by a system for classification of surfactants. Included is a short list of products (European and American) by trade name, type, and active ingreident content. An excellent discussion of physicochemical properties as dependent upon homologous nature is given. Tables summarizing properties of surfactants as correlated with structure can prove most helpful.

An understanding discussion of practical information on builders, combinations of surfactants, auxiliary agents, various drying methods, and formulation is given. A considerable section is devoted to practical applications, with examples. Analytical procedures for identification and quantitative determination are given.

Of general interest for comparison purposes is a short section indicating world-wide production and consumption data.

The book is well indexed; literature references are voluminous and accurate. Included under the bibliography is an interesting critique of published tests and references.

While not specifically aimed at the textile chemist, this book can prove a valuable reference because the author, based on his wide experience, has carefully selected only the most pertinent information and has presented it in concise, easily utilized form.

Chromatography: A Review of Principles and Applications. E. and M. Lederer. Houston, Texas, and Amsterdam, Netherlands, Elsevier Press, 1954. xvii + 460 pages. Price, $9.25.

Reviewed by Ludwig Rebenfeld, Textile Research Institute, Princeton, New Jersey

Ever since the classical work of Tswett at the turn of the century it has been realized that separation of closely related substances is possible by means of adsorption chromatography. The modern concept of partition chromatography, introduced by Martin and Synge in 1941, served to provide the needed impetus to all forms of chromatographic separation. Our understanding of the fundamental theory of chromatography has not been able to keep pace with the wide applications of this method of separation, and for this reason most of the accepted methods are empirical in nature.

This book is probably the most complete treatise dealing with this reborn separation and purification technique. It will be extremely useful to the chemist who is in need of a comprehensive survey of the chromatography field. Little attention is paid to the uncertain theory and mechanism of chromatography, although a brief discussion of the presently accepted concepts is presented.

Adsorption chromatography, ion exchange chromatography, and partition chromatography constitute the first three divisions of the book, where a general discussion of the techniques, apparatus, and methodology of each are to be found. The technique of paper partition chromatography, which has in recent years found wide application especially in the field of natural organic products, is treated in the third division of the book. The fourth division deals with the application of all three types of chromatography to organic materials where such varied substances as carbohydrates, proteins, dyestuffs, amino

acids, lipids, hormones, and vitamins are considered. The fifth division deals with the chromatography of inorganic substances, with the major emphasis being placed on the qualitative and quantitative analysis of the metals.

Unfortunately many topics are not fully developed, and the principal use of this treatise will be as a source book for the laboratory investigator; and reference to the original literature will be mandatory. A bibliography is given with over 2000 references through 1952; however, no attempt is made at a critical examination of the available literature.

All about the Chemistry of **Cotton . . .**

CHEMISTRY AND CHEMICAL TECHNOLOGY OF COTTON

Edited by KYLE WARD, Jr., *The Institute of Paper Chemistry, Appleton, Wisconsin.*

This book serves as an introduction and refresher in chemistry to the cotton textile men and to the textile chemist who needs specific information about cotton textiles and their behavior. Under the guidance of experts in research and application, the reader is led through the different steps of cotton treatment. This is the first comprehensive treatment in the English language of the chemical aspects of cotton technology.

1955. 801 pages, 86 illus., 78 tables. $20.00

THE PHYSICAL CHEMISTRY OF DYEING

Second completely revised and augmented edition.

By THOMAS VICKERSTAFF.

Of paramount importance to everyone interested in dyes or dyeing, this book treats dyeing as a physical chemical process to which may be applied the usual quantitative methods of physical chemistry.

1954. 522 pages, 137 illus. $7.50

FIBER MICROSCOPY

A Textbook and Laboratory Manual

By A. N. J. HEYN, *Professor of Natural and Synthetic Fibers, Clemson Agricultural College, Clemson, S. C.*

Textile testing, solution of practical mill problems, control of fiber manufacturing processes, and textile research are made easy by using Heyn's FIBER manual.

1953. 396 pages, 37 illus., 6 tables. $5.50

INTERSCIENCE PUBLISHERS, INC.

250 Fifth Avenue, New York 1, N.Y.

SENIOR RESEARCH POSITIONS

at **Celanese**

ENGINEER
Degree in Physics, Mechanical or Textile Engineering. To develop basic understanding of fiber usage from an engineering point of view, including studies on conversion of fibers into yarns, yarns and continuous filaments into fabrics, and fabrics into end use products.

CHEMIST
Ph.D. or equivalent in Physical Chemistry, 5 to 8 years' experience, some of which should have been in fiber research. To assist in planning and coordinating problems in basic fiber research covering relationship of molecular and micro structure to mechanical, thermal and other physical properties.

PHYSICIST
3 to 5 years experience in colorimetry and spectrometry. To develop methods and direct spectrophotometric analyses of dyestuffs, pigments and textile materials and to interpret results for use in solution of research problems.

These and other similar positions are open at Celanese's Research Laboratories in Summit, New Jersey. The labs are fully equipped with modern facilities, contributing to a satisfying working environment. The diversity of Celanese's activities forms the basis for a permanent, worthwhile association.

Applications are invited from qualified men.
Please address **Mr. J. A. Berg.**
All replies in confidence.

CELANESE CORPORATION OF AMERICA
Morris Court **Summit, New Jersey**

T.R.I.'s Annual Review of Research and Development

Review of Textile Research and Development During 1954. Prepared by the staff of Textile Research Institute, Princeton, New Jersey. Price $5.00.

Published previously in the May issue of TEXTILE RESEARCH JOURNAL, the "Review" for 1954 with classified bibliography of 2000 literature references will be ready for distribution in May as a bound report. It will not appear in the JOURNAL.

Orders for copies should be sent to:

Textile Research Institute
Princeton, New Jersey

News about

B. F. Goodrich Chemical *raw materials*

Looking for ways to improve textile products?

Check these *Hycar* Latex advantages

Apply this reference listing of the uses for Hycar latex to your textile products or applications. It may give you helpful ideas—point the way to developing or improving more saleable products. For further information and a fact-filled booklet on Hycar latex, please write Dept. BX-1, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

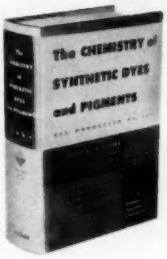
fabrics	Use Hycar Latex—
cotton	....as a permanent warp yarn size to provide abrasion resistance during weaving; and wear resistance to the finished fabric; ....as after-treatment to improve wearing qualities and to provide a full hand; ....as a carrier for specialty active agents such as fungicides and flame proofing chemicals; ....as a binder for waxes and metallic salts used for water repellency or stain resistance.
rayon	....as permanent warp yarn size with starch for increased seam strength.
rayon cotton	....with urea-formaldehyde resin to prevent deterioration of fibers when large amounts of U-F resin are used for crease and wrinkle resistance; ....as a binder for pigment coloring and printing; ....as a binder for non-woven fabrics.
cotton wool	....as after-treatment to reduce crock particularly with red naphthol dyes.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Hycar Latex

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

Reinhold Books to solve textile problems . . .



1. THE CHEMISTRY of SYNTHETIC DYES and PIGMENTS

Edited by H. A. LUBS
Organic Chemicals Dept.,
E. I. duPont de Nemours & Co.

With Contributions by Leading Authorities
ACS MONOGRAPH No. 127

The most authoritative work ever published on the subject of synthetic dyes! Compact, thoroughly up to date, much of the information has never been available before in book form, notably that an the new phthalocyanines.

Each of the 19 contributors has spent the major part of his scientific life in the field of dyes and intermediates, and all have been staff members of DuPont's Jackson Laboratory—known throughout the world as a pioneer center for the research and development of synthetic organic chemicals. Each product selected for discussion was chosen for its commercial or scientific importance.

1955 752 pages $18.50

3. INDUSTRIAL DETERGENCY

Edited by WILLIAM W. NIVEN, Jr., Mgr., Chemical Eng. Div., Midwest Research Institute, Kansas City

Thoroughly up-to-the-minute, practical treatment of methods, material and equipment used for industrial cleaning. Covers the compositions of detergents for specific applications, how detergents are used, factors determining choice and usage for particular jobs, problems that arise and how to overcome them, how final results are evaluated and future trends.

1955 340 pages $8.75

4. WOOL: ITS CHEMISTRY and PHYSICS

By PETER ALEXANDER and ROBERT F. HUDSON

The *first* truly comprehensive treatment of the chemical, physical, and biological characteristics of wool ever published, and the *only* book to collect this widely scattered data into one convenient source. Practical industrial application of the basic physics and chemistry are fully explored. Easy to read and use. Written by two leading English textile chemists.

1954 416 pages $10.00

5. TEXTILE FIBERS, YARNS, and FABRICS

A Comparative Survey of Their Behavior With Special Reference to Wool

By ERNEST R. KASWELL, Associate Director, Fabric Research Laboratories, Boston.

Based on the *research results* of over 400 investigators, this book is the first to evaluate the engineering, physical, and chemical behavior of textile fibers, yarns, and fabrics, both natural and synthetic. *All* fibers, including such recent synthetics as Dacron, Vicara, and X-51, are fully discussed.

1953 568 pages $11.00

REINHOLD PUBLISHING CORP.,
430 Park Avenue, New York 22, N. Y.

2. DETERIORATION of MATERIALS

Causes and Preventive Techniques

Edited by GLENN A. GREATHOUSE, Director, and CARL J. WESSEL, Asst. Director, Prevention of Deterioration Center, Div. of Chem. and Chem. Technology, National Academy of Science—National Research Council.

With a foreword by VANNEVAR BUSH

Prepared by a staff of 21 specialists, the book analyses the causes of deterioration and presents a vast range of *proven* techniques for overcoming it.

Nowhere else can you find such a wealth of information so vitally needed by all industry for prolonging the life of raw materials, equipment, and products.

Special attention is devoted to the problems of the textile industry. Transporters and storage agencies will also find the book of exceptional value in establishing protective measures.

1954 850 pages Over 200 illustrations $12.00

6. TEXTILE CHEMICALS and AUXILIARIES

Edited by HENRY C. SPEEL, Technical Consultant

Deals with the role of chemicals, finishing agents, and auxiliaries in modern textile industry; covers the physical and chemical properties of natural, semisynthetic, and fully synthetic fibers. Describes the general processes used in preparation; dyeing and printing; and finishing. Covers such topics as water and its conditioning; use of fats and oils; gums and glues; solvents; and flameproofing agents.

1952 505 pages $10.00

7. MICROBIAL DECOMPOSITION of CELLULOSE

By RALPH G. H. SIU, Research Director, Pioneering Research Laboratories, U.S.Q.M.C., Research Associate, Howard University.

The only comprehensive collection of facts and data dealing dealing with the whole story of fungus and bacterial attack on cotton fabrics. Offers invaluable help in preventing the billons of dollars annual damage resulting from these causes. Gives a clear picture of the structure of cellulose; the biochemical mechanism of its decomposition; the physiology and manner of attack of the microorganisms; and methods of preventing attack and protecting materials against deterioration.

1951 538 pages $12.00

EXAMINE ANY OR ALL of these helpful and informative BOOKS—FREE!

Use this coupon for FREE 10-DAY EXAMINATION

REINHOLD PUBLISHING CORP., Dept. M-798,
430 Park Ave., New York 22, N. Y.

Send me the book(s) I have marked with circle(s) below for 10 days FREE EXAMINATION. In 10 days I will either return the book(s) and owe nothing, or will send the purchase price plus postage.

(1) (2) (3) (4) (5) (6) (7)

Name .....

Address .....

City ..... Zone ..... State .....

☐ SAVE MONEY! Enclose purchase price *now* and Reinhold pays all shipping charges. Same return privileges; refund guaranteed. Please include 3% sales tax on New York City orders.

Platt's Metallic Wire for COTTON or WORSTED CARDS

Sold by

Ashworth

Offers 3 POINT PROFIT PROGRAM

Platt's Metallic Wire for your cards, in place of flexible card clothing, is suitable for certain classes of work on cotton, worsted or synthetic fibre cards. Its suitability for YOUR purposes should be determined by consultation with us.

It offers the following 3 point profit program:

1. Increased production.
2. Marked decrease in stripping.
3. Elimination of grinding.

Let us analyze your carding problem to see if Platt's metallic wire for your cards will make money for you.

ASHWORTH BROS., INC.

American Card Clothing Co. (Woolen Division)

Fall River*†‡ Worcester‡ Philadelphia*†‡ Atlanta†‡ Greenville*†‡

Charlotte†‡ Dallas†‡ (Textile Supply Co.)

*Factory †Repair Shop ‡Distributing Point

E. G. PAULES COMPANY

Western Representative Los Angeles 62, Calif.

3 Factories ● 6 Repair Shops ● 7 Distributing Points

PRODUCTS AND SERVICES

Clothing for Cotton, Wool, Worsted, Silk, Synthetic Fibre and Asbestos cards and for All Types of Napping Machinery. Brusher Clothing and Card Clothing for Special Purposes. Lickerin Wire and Garnet Wire. Sole Distributors for Platt's Metallic Wire. Lickerins and Top Flats Reclothed.

CRUSH-RESISTANT, WRINKLE-DEFYING COTTONS THAT MANY WASHINGS WON'T DISCOURAGE—YOURS WITH

RHONITE R-1*

Our wise little owl knows that cotton dress goods (or rayons or blended fabrics) become wonderfully wrinkle-resistant when treated with RHONITE R-1. Even repeated washings won't take away their fresh, springy beauty.

RHONITE R-1 treated fabrics can be calender-finished for a wide range of effects—from friction to deep embossed, from plain to moiré.

***RHONITE R-1** is another dependable chemical product for the textile industry made by the makers of LYKOPON.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

RHONITE *and* LYKOPON *are trade-marks, Reg. U.S. Pat. Off. and in principal foreign countries.*